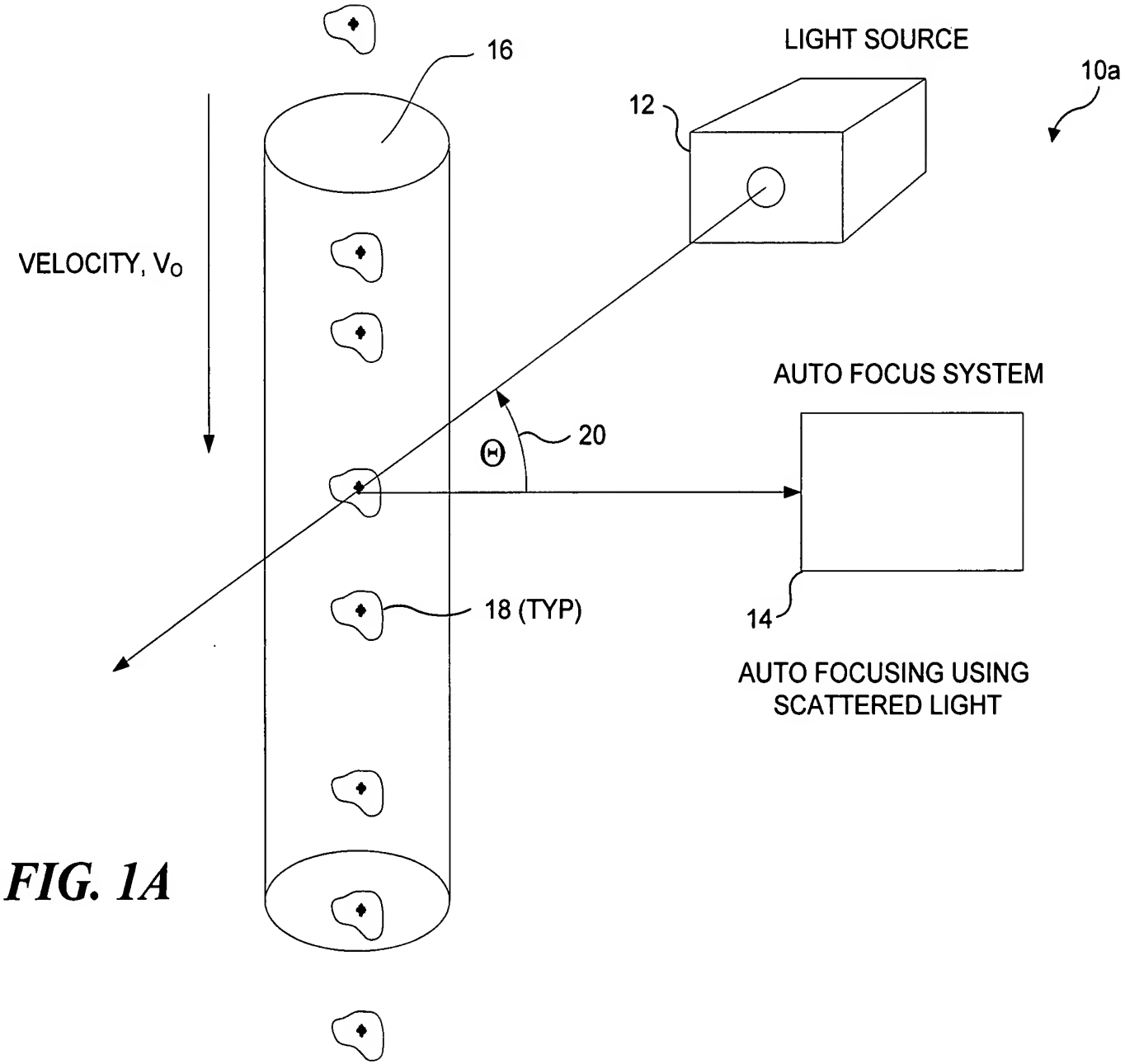

16
LIGHT SOURCE
10a
12
VELOCITY, V_O
AUTO FOCUS SYSTEM
20
Θ
18 (TYP)
14
AUTO FOCUSING USING
SCATTERED LIGHT

FIG. 1A

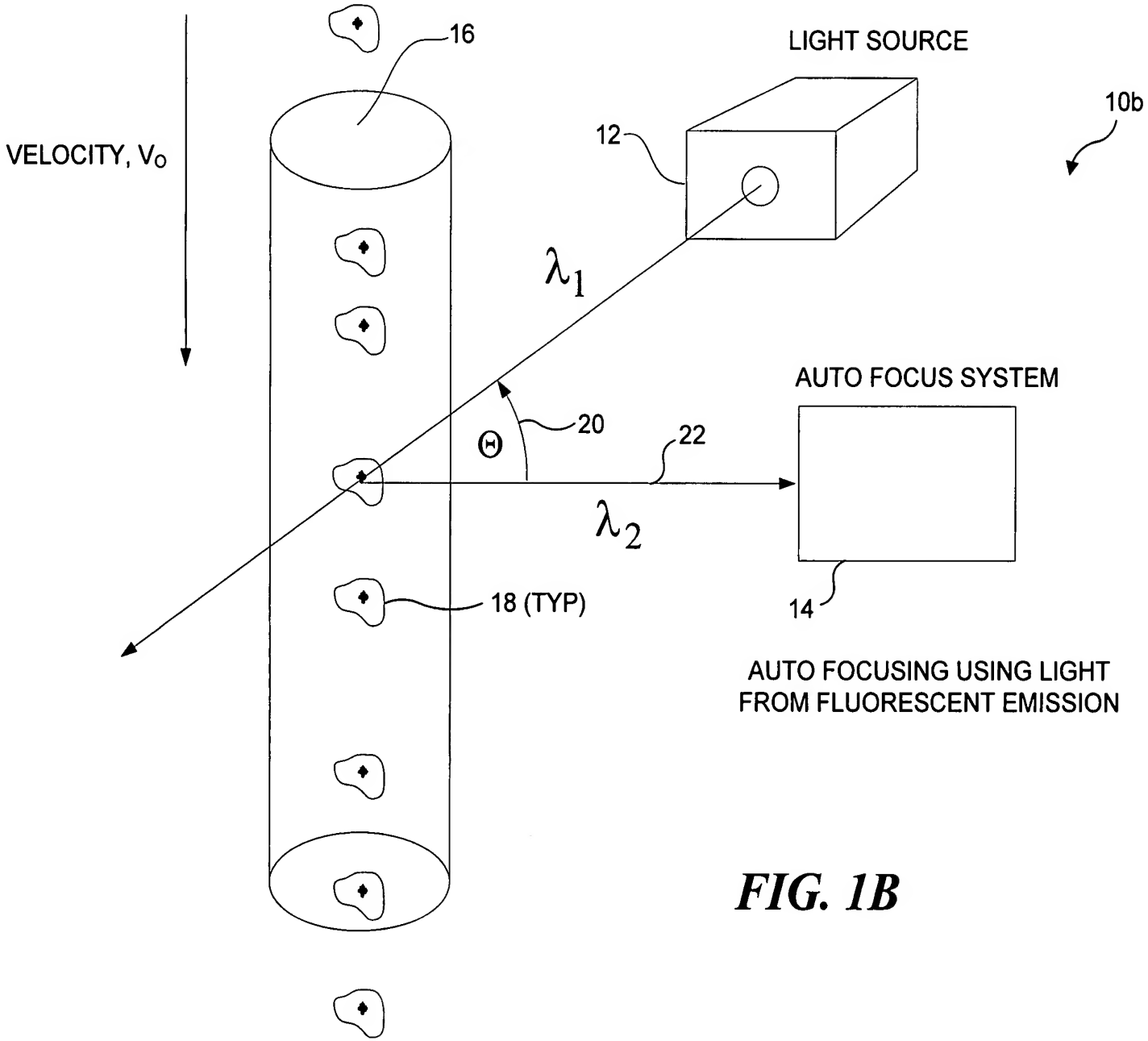

VELOCITY, V_O
16
LIGHT SOURCE
10b
12
λ_1
AUTO FOCUS SYSTEM
20
Θ
22
λ_2
18 (TYP)
14
AUTO FOCUSING USING LIGHT
FROM FLUORESCENT EMISSION

FIG. 1B

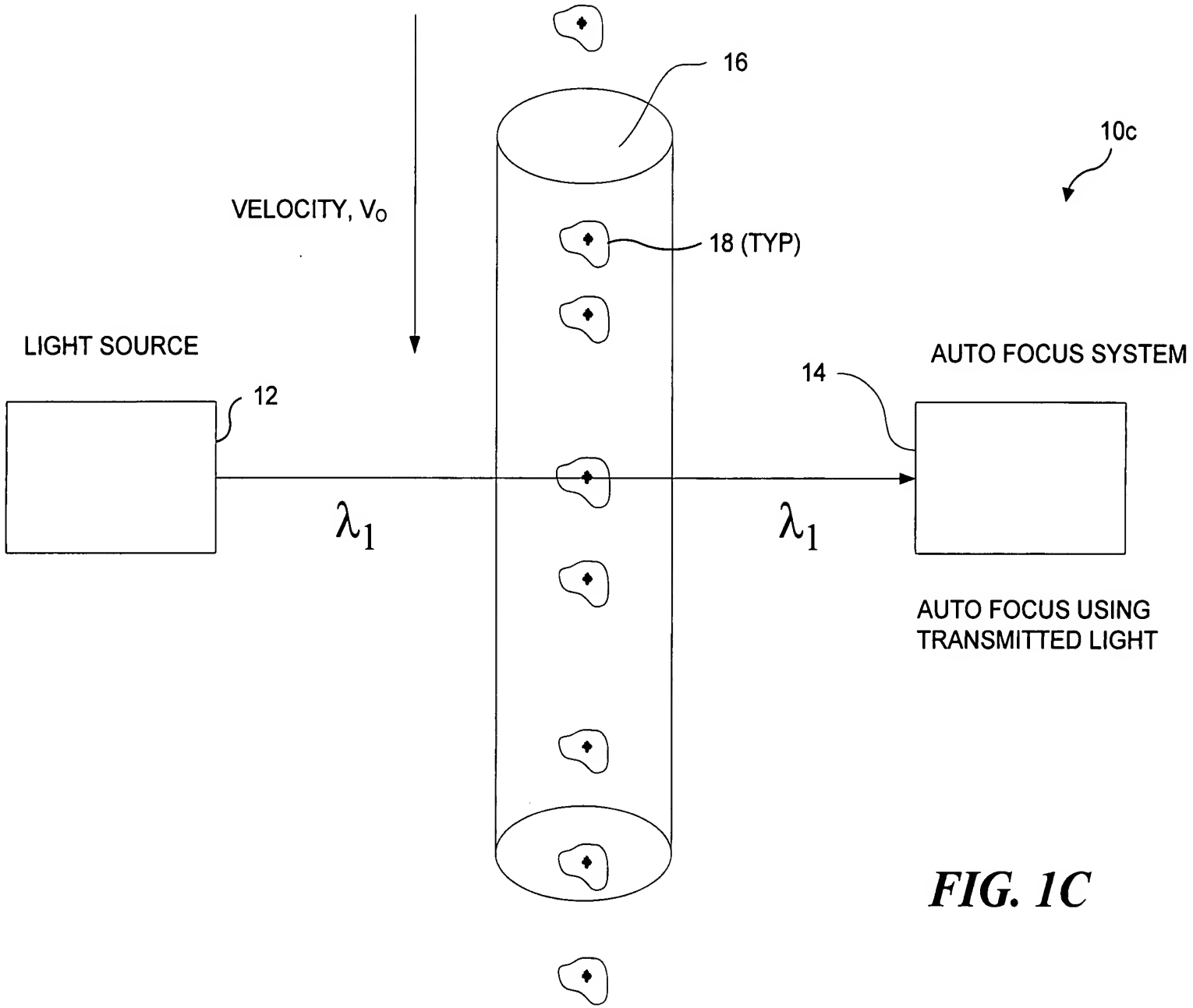
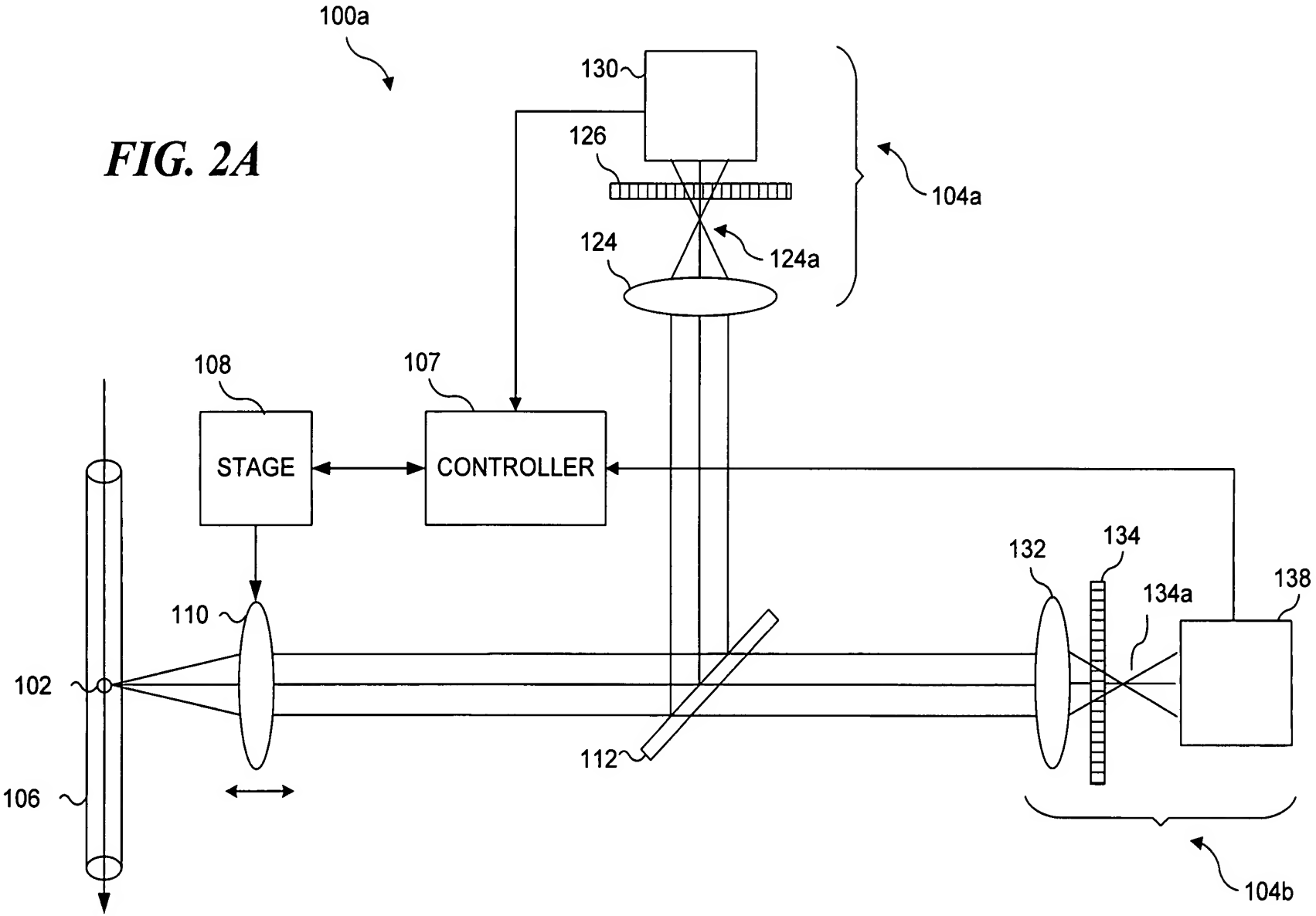

16
10c
VELOCITY, V_O
18 (TYP)
LIGHT SOURCE
AUTO FOCUS SYSTEM
14
12
λ_1
λ_1
AUTO FOCUS USING
TRANSMITTED LIGHT

FIG. 1C

FIG. 2A


100a
130
126
124
124a
104a
108
107
STAGE
CONTROLLER
110
102
106
112
132
134
134a
138
104b

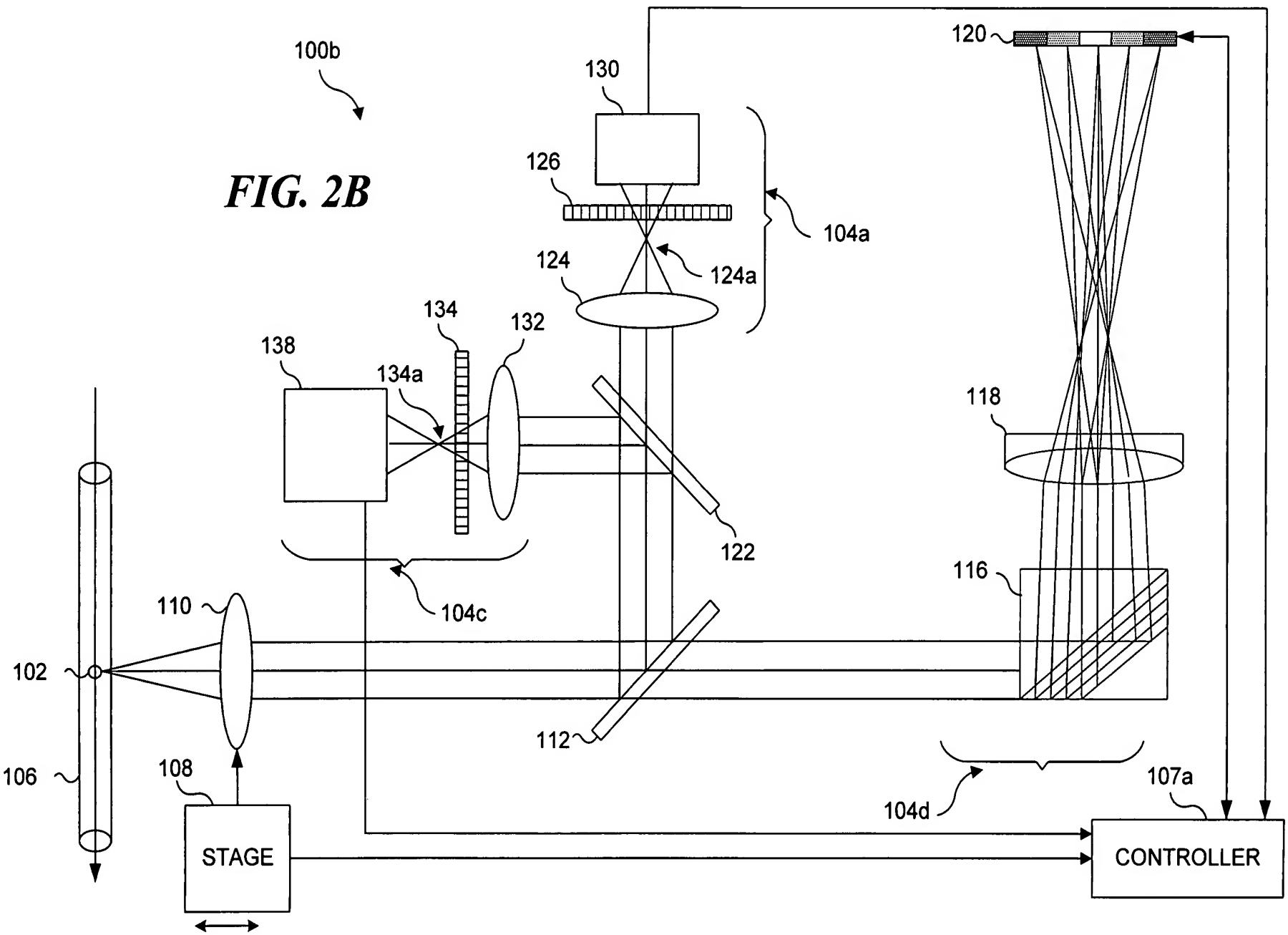

100b
130
120
126
104a
124
124a
134
132
138
134a
118
122
116
104c
110
102
112
106
108
104d
107a
STAGE
CONTROLLER

FIG. 2B

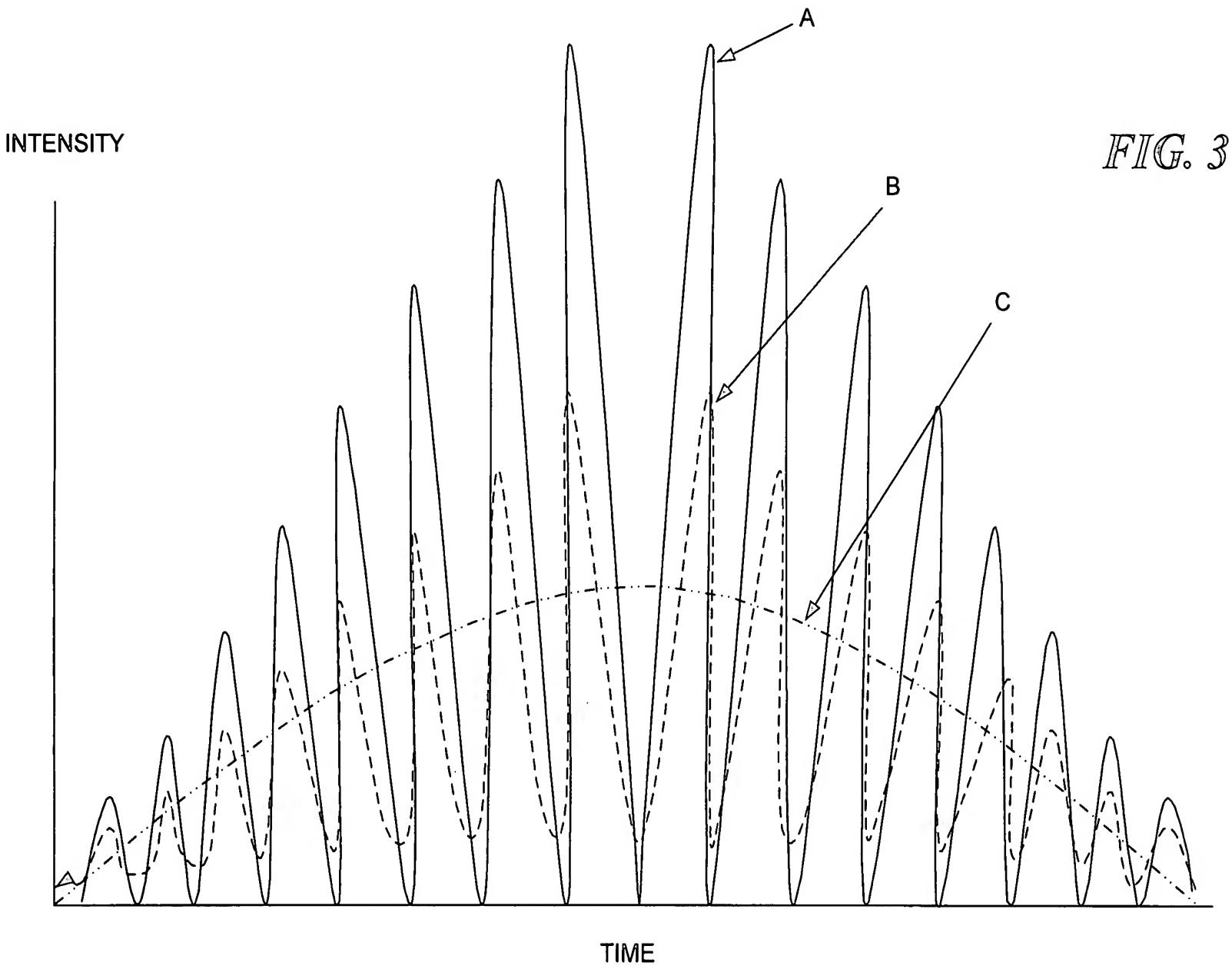


FIG. 3

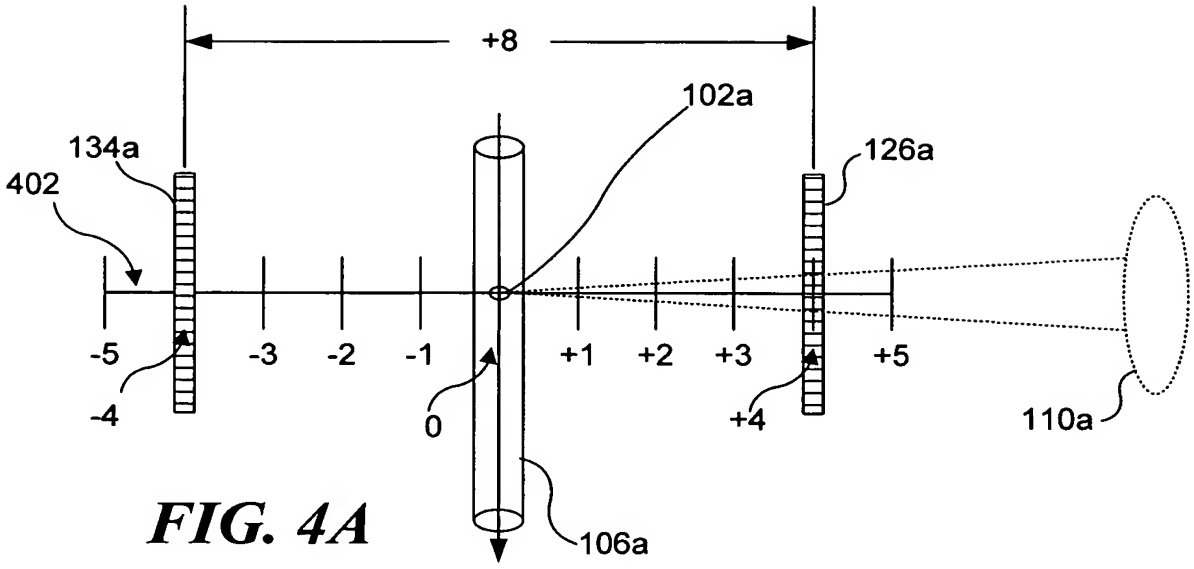


FIG. 4A

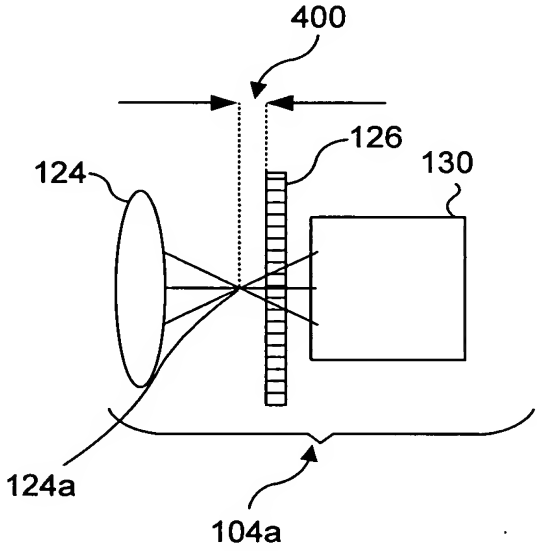


FIG. 4B

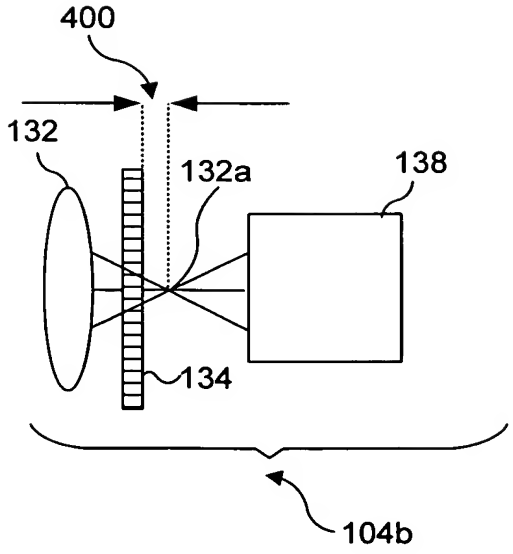


FIG. 4C

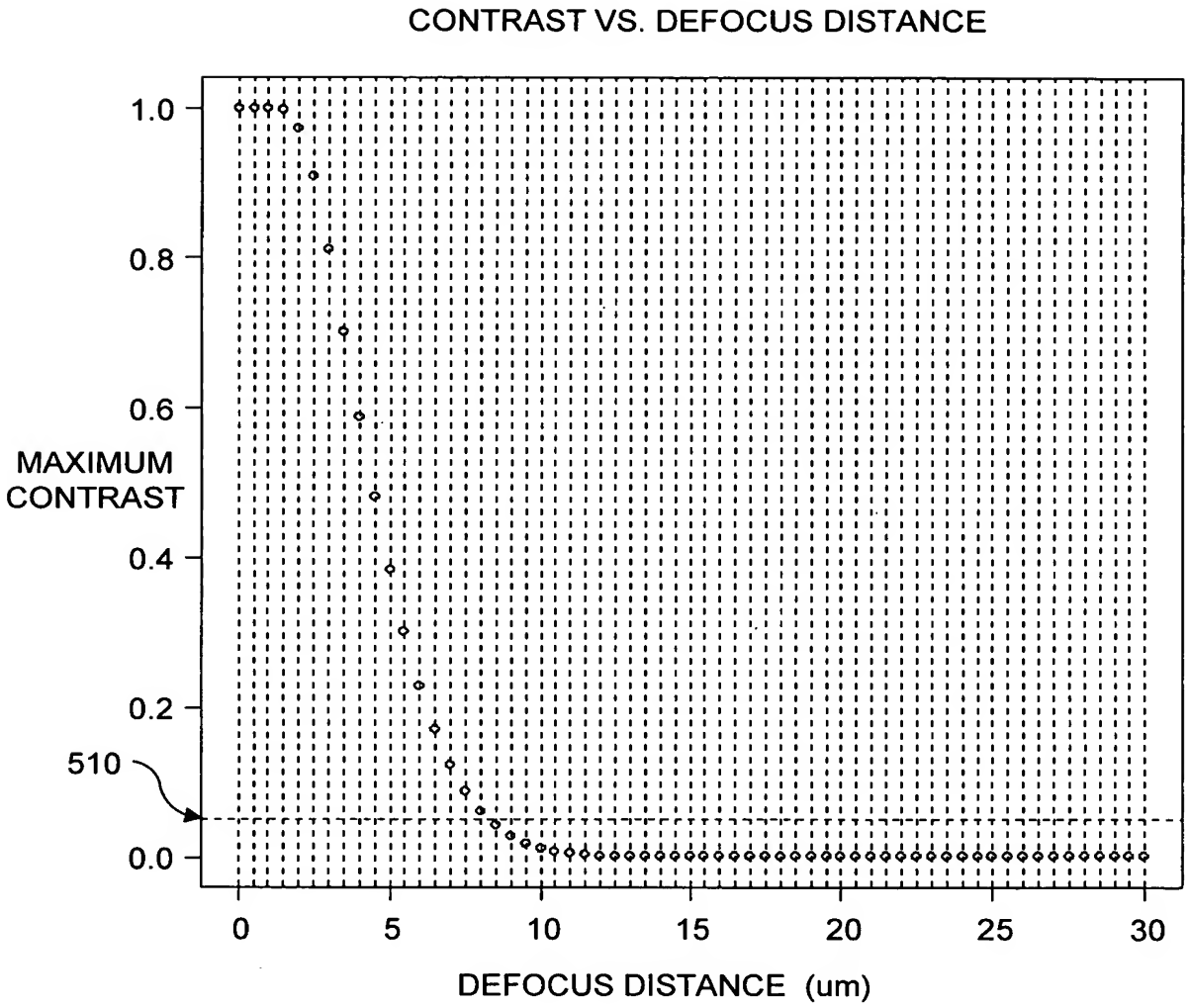

CONTRAST VS. DEFOCUS DISTANCE
1.0
0.8
0.6
MAXIMUM
CONTRAST
0.4
0.2
510
0.0
0
5
10
15
20
25
30
DEFOCUS DISTANCE (um)

FIG. 5A

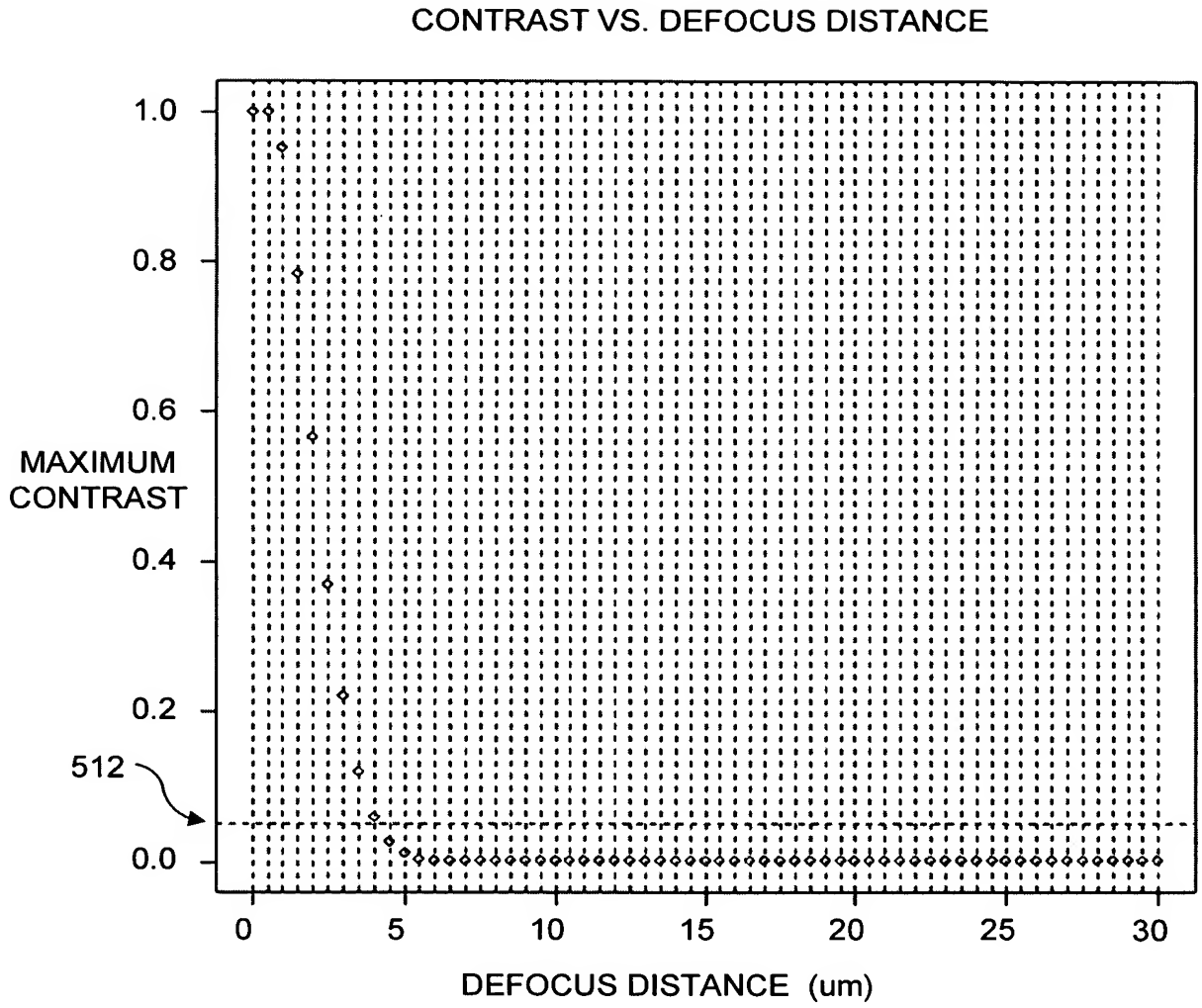

CONTRAST VS. DEFOCUS DISTANCE
1.0
0.8
0.6
MAXIMUM
CONTRAST
0.4
0.2
512
0.0
0
5
10
15
20
25
30
DEFOCUS DISTANCE (um)

FIG. 5B

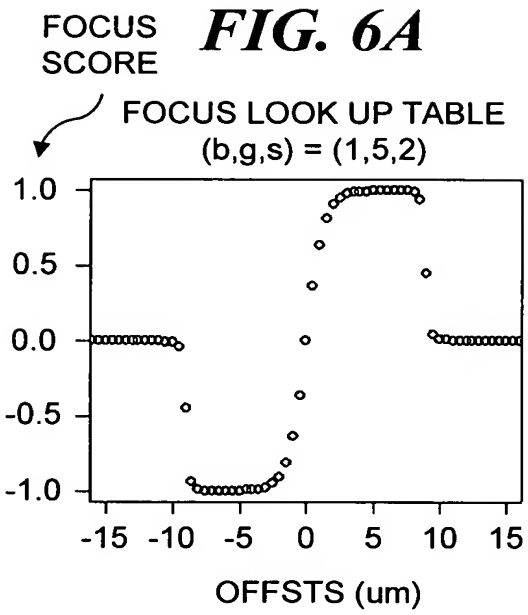


FIG. 6A

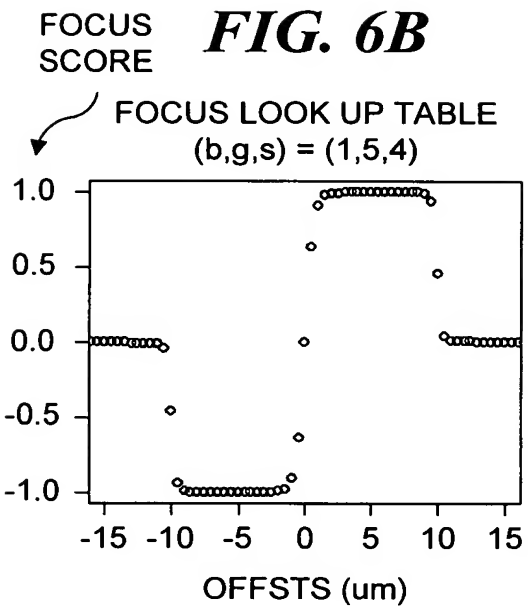


FIG. 6B

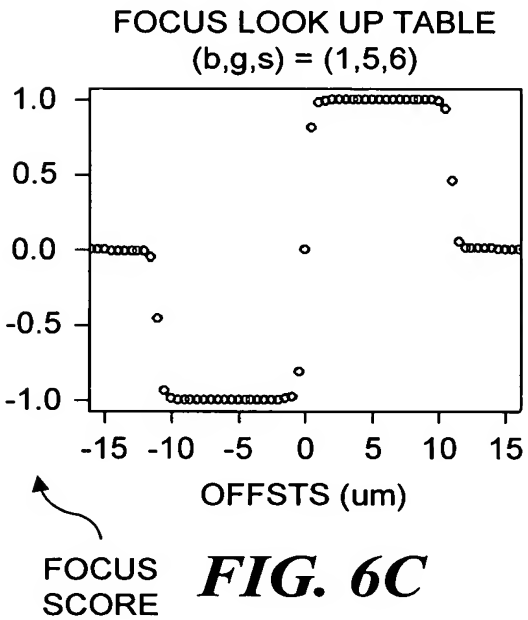


FIG. 6C

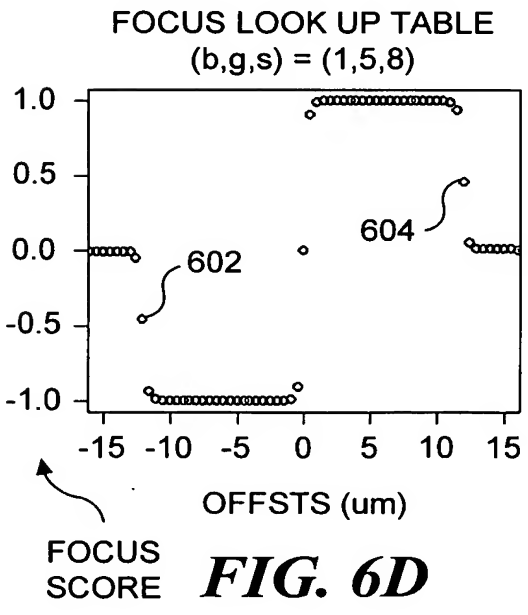


FIG. 6D

FIG. 7A

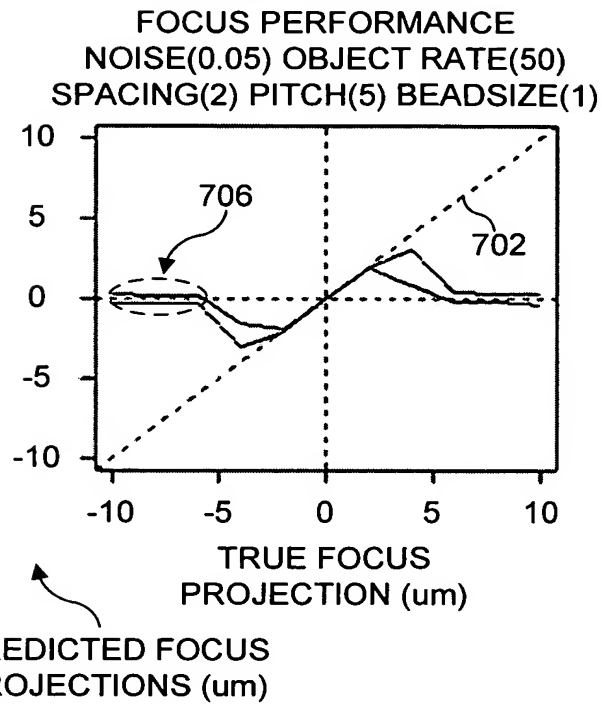


FIG. 7B

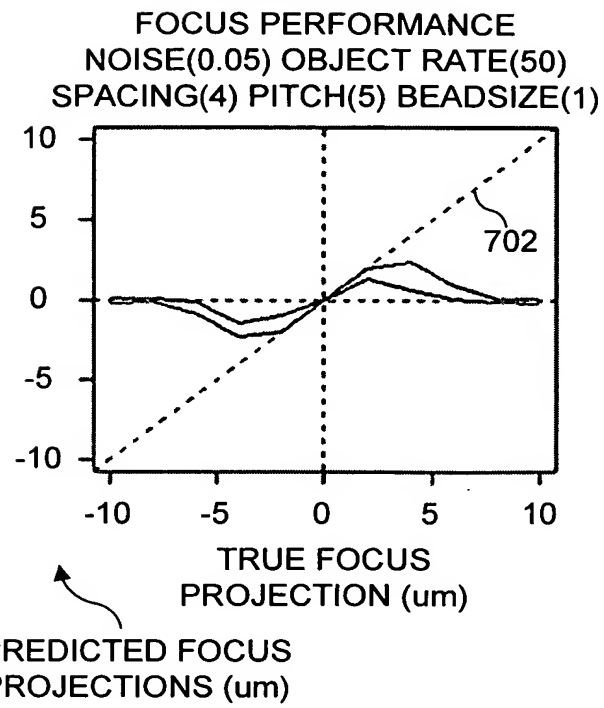


FIG. 7C

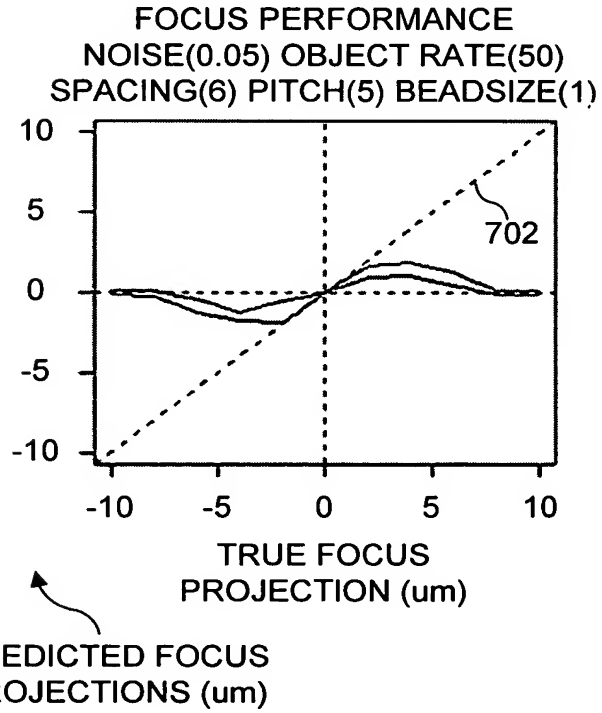


FIG. 7D

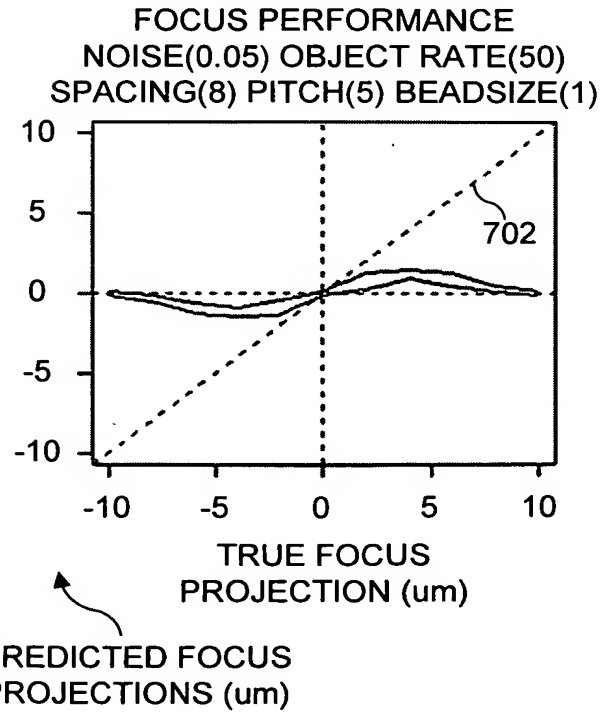


FIG. 8A

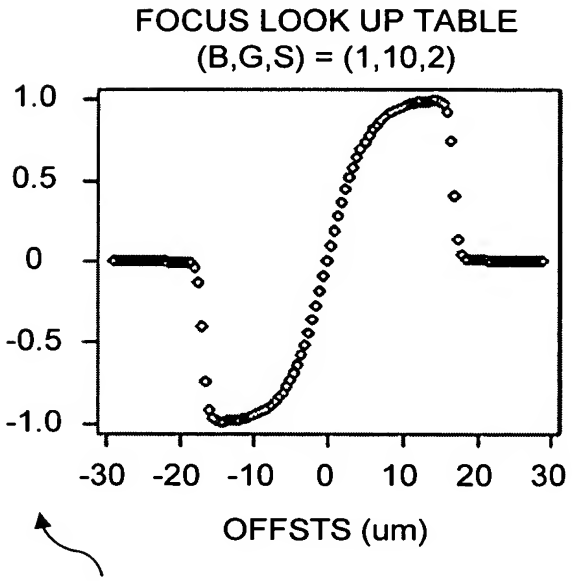


FIG. 8B

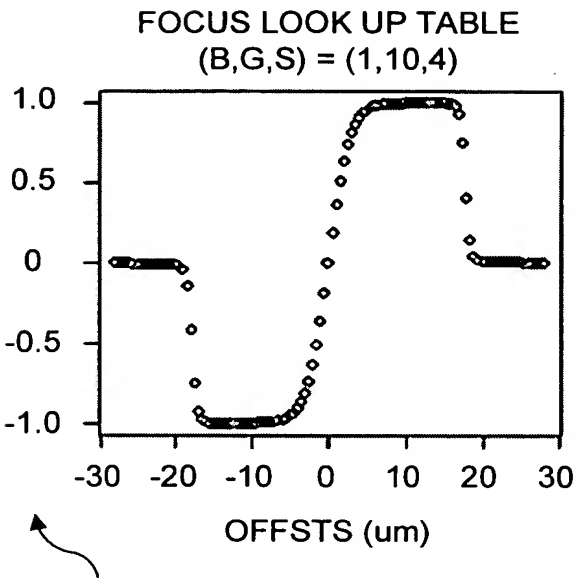


FIG. 8C

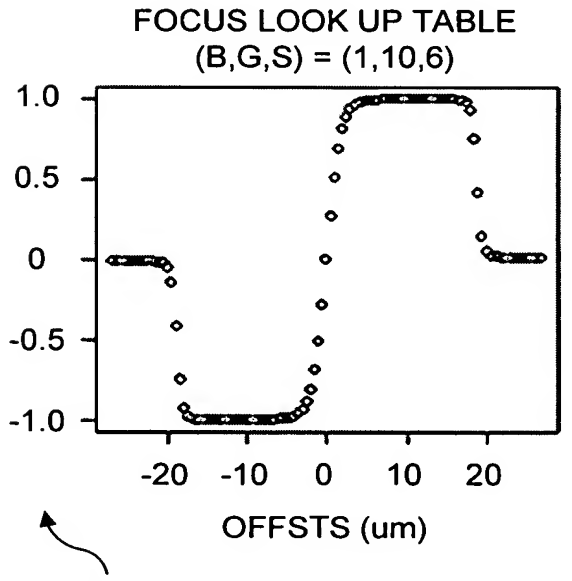


FIG. 8D

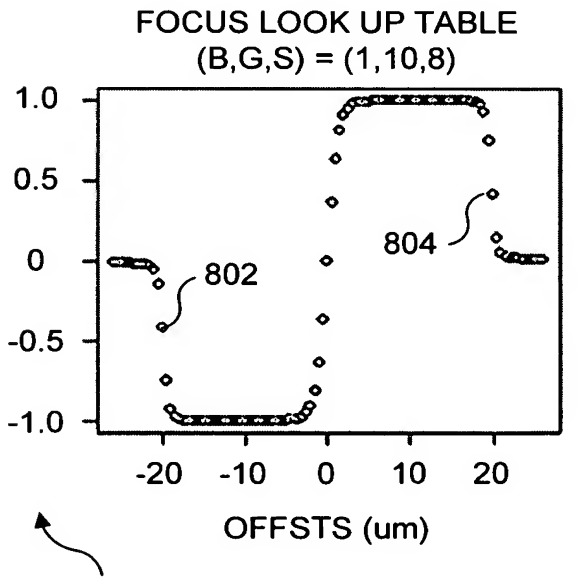


FIG. 9A

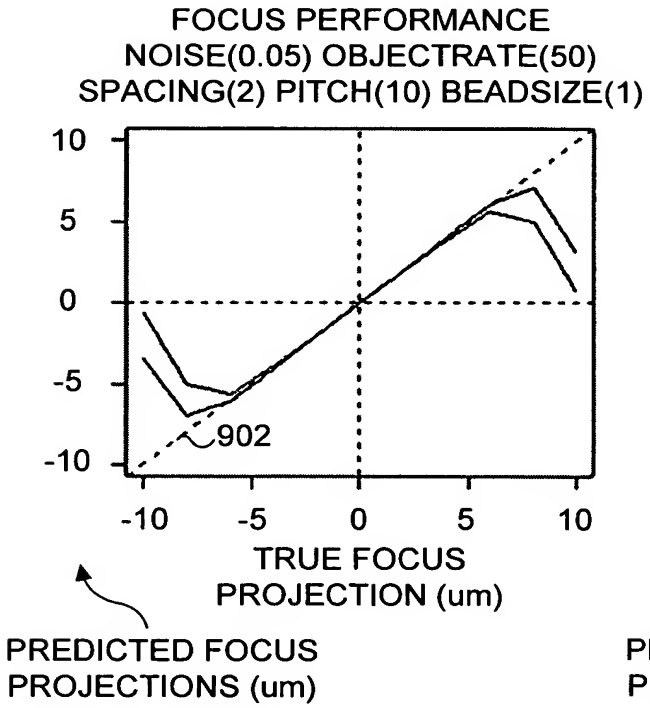


FIG. 9B

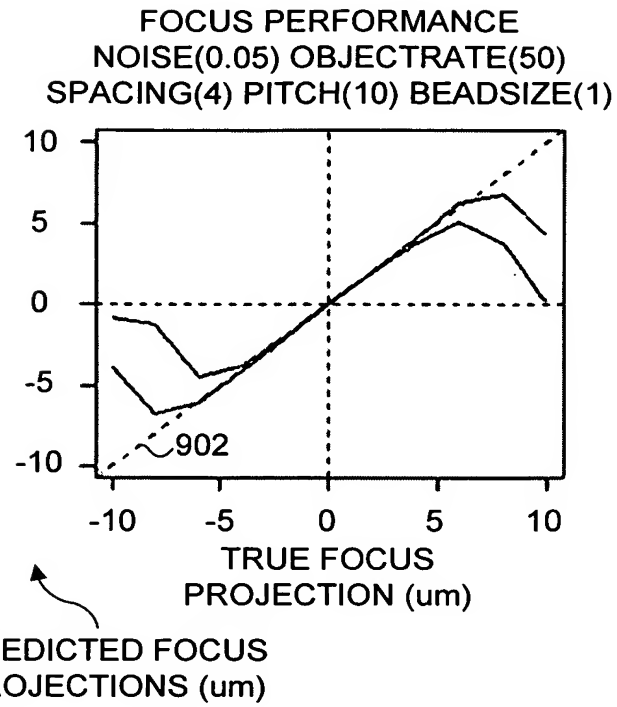


FIG. 9C

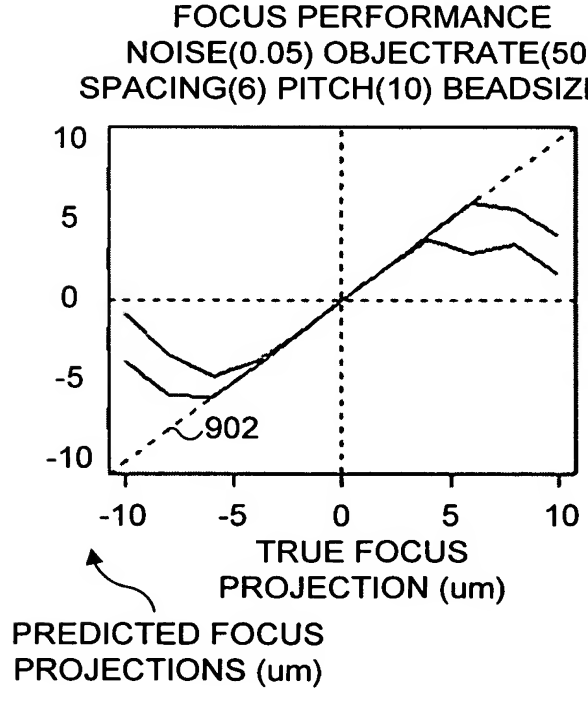
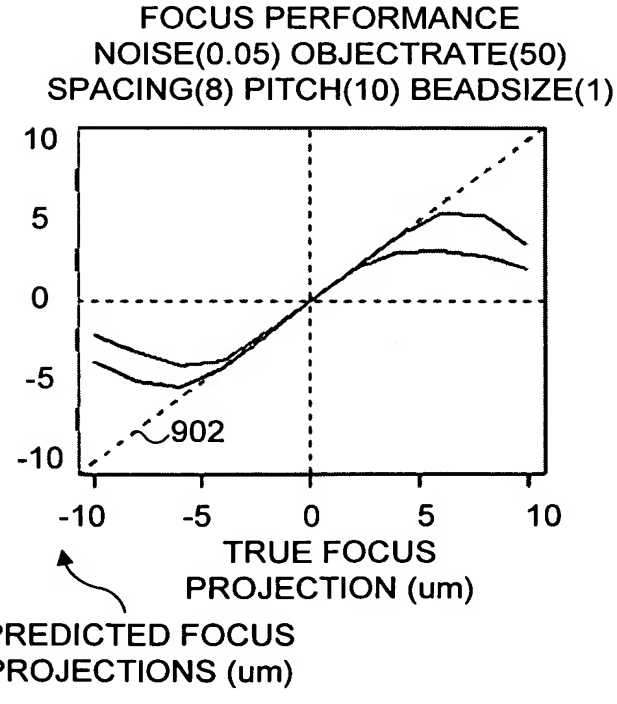


FIG. 9D



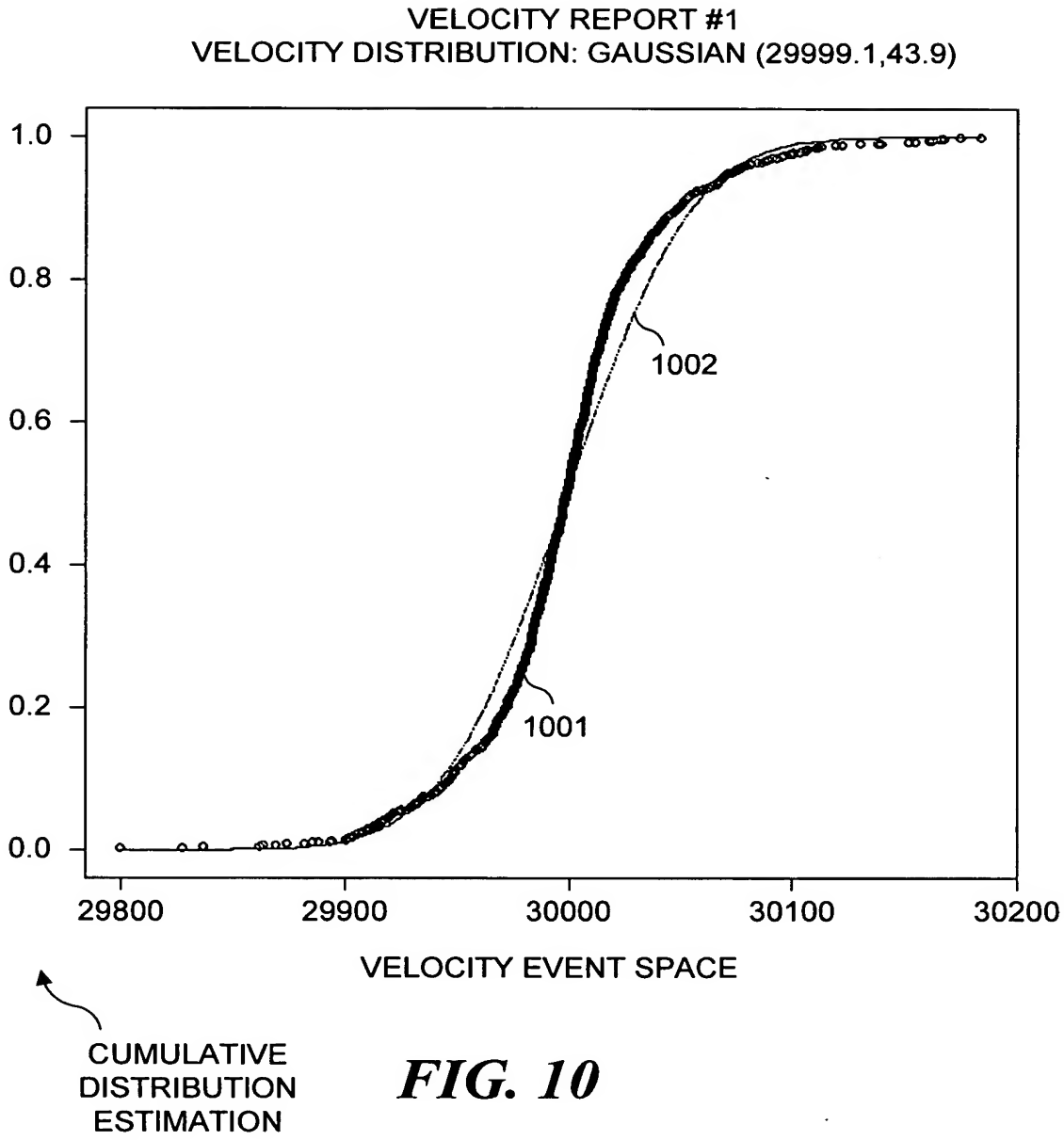

VELOCITY REPORT #1
VELOCITY DISTRIBUTION: GAUSSIAN (29999.1,43.9)
1.0
0.8
0.6
0.4
0.2
0.0
1002
1001
29800
29900
30000
30100
30200
VELOCITY EVENT SPACE
CUMULATIVE
DISTRIBUTION
ESTIMATION

FIG. 10

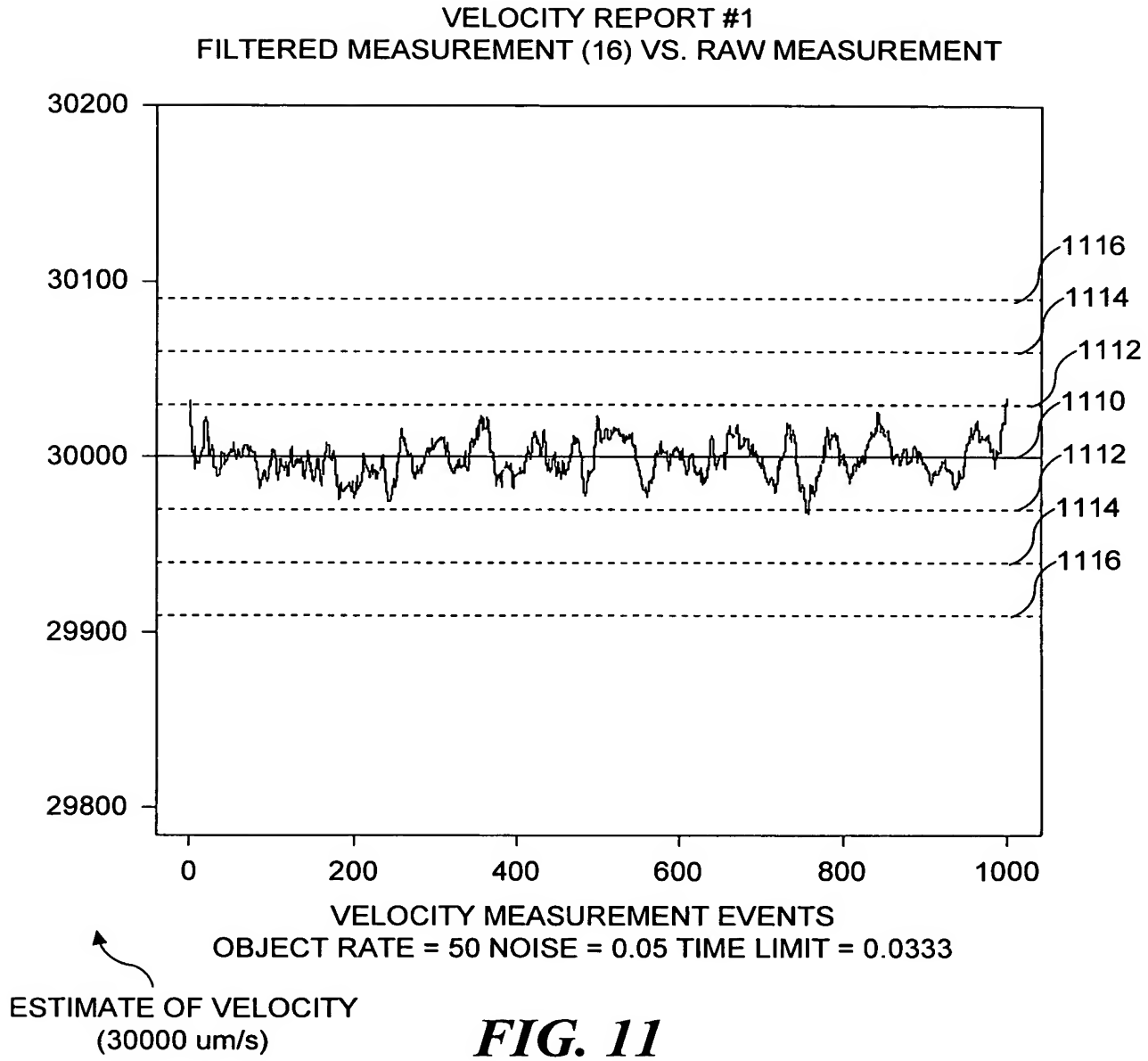

VELOCITY REPORT #1
FILTERED MEASUREMENT (16) VS. RAW MEASUREMENT
30200
30100
30000
29900
29800
1116
1114
1112
1110
1112
1114
1116
0
200
400
600
800
1000
VELOCITY MEASUREMENT EVENTS
OBJECT RATE = 50 NOISE = 0.05 TIME LIMIT = 0.0333
ESTIMATE OF VELOCITY
(30000 um/s)

FIG. 11

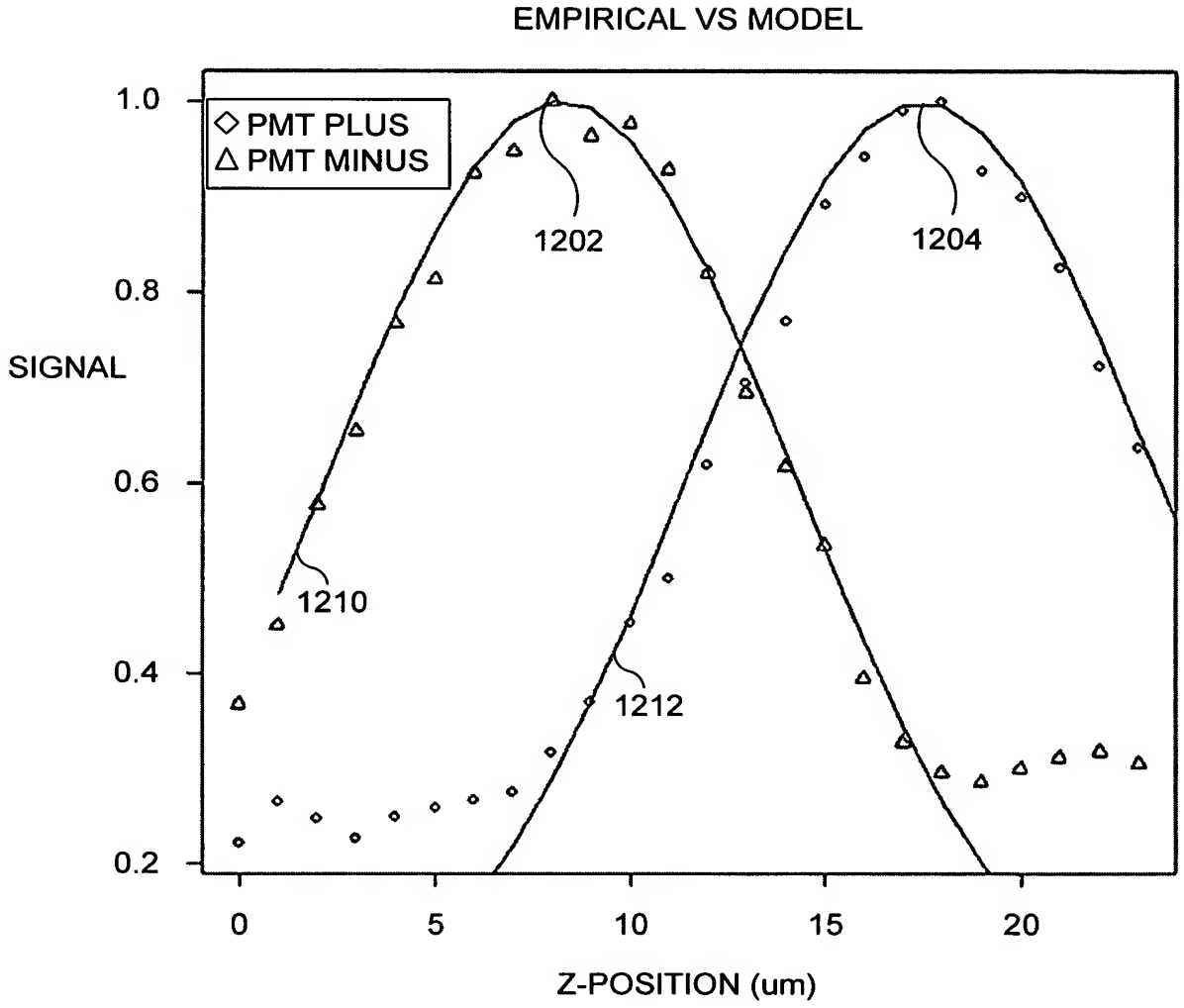

EMPIRICAL VS MODEL
PMT PLUS
PMT MINUS
1202
1204
1210
1212
SIGNAL
1.0
0.8
0.6
0.4
0.2
0
5
10
15
20
Z-POSITION (um)

FIG. 12

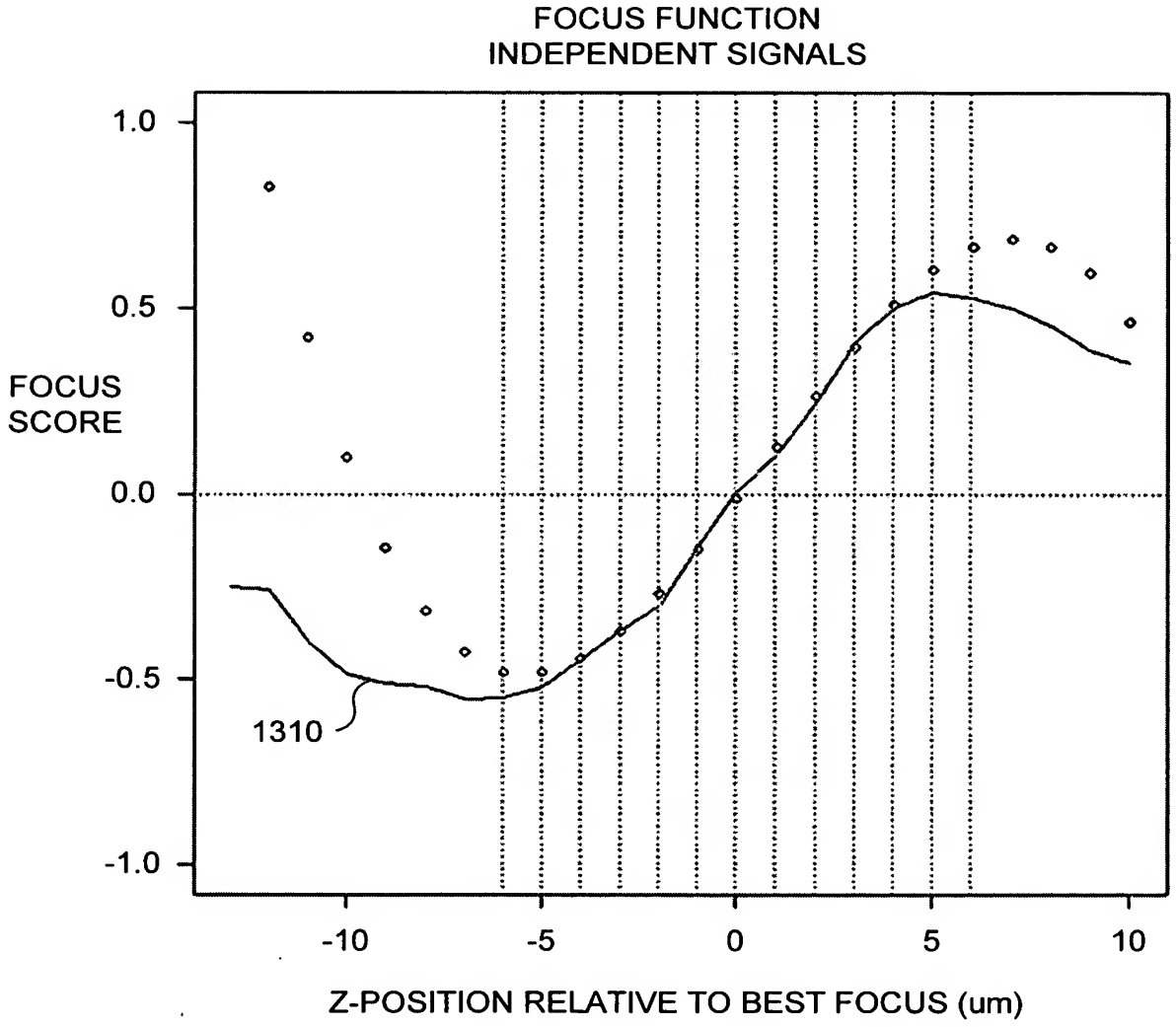

FOCUS FUNCTION
INDEPENDENT SIGNALS
1.0
0.5
0.0
-0.5
-1.0
FOCUS
SCORE
1310
-10
-5
0
5
10
Z-POSITION RELATIVE TO BEST FOCUS (um)

FIG. 13

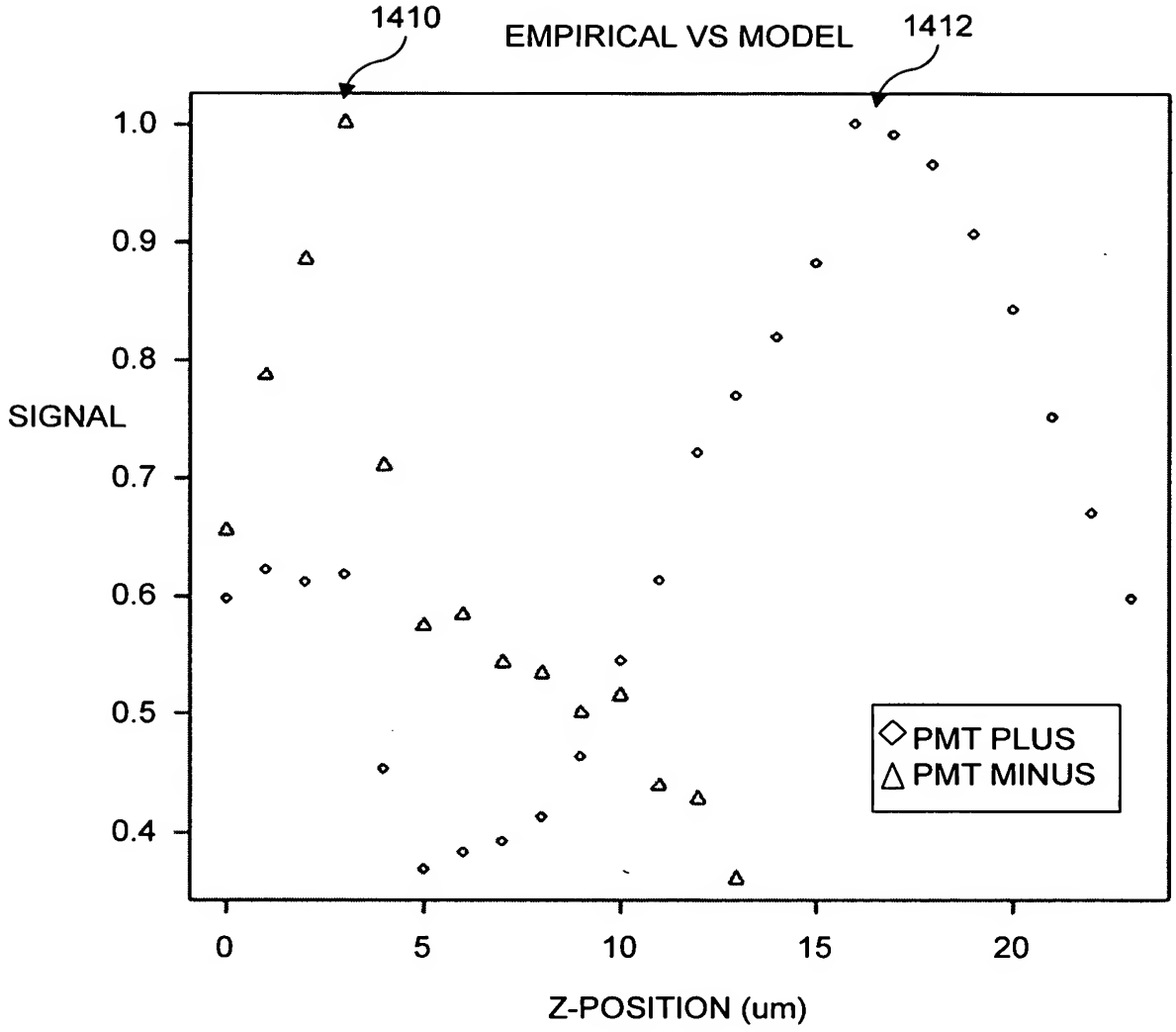

1410
EMPIRICAL VS MODEL
1412
1.0
0.9
0.8
SIGNAL
0.7
0.6
0.5
0.4
PMT PLUS
PMT MINUS
0
5
10
15
20
Z-POSITION (um)

FIG. 14

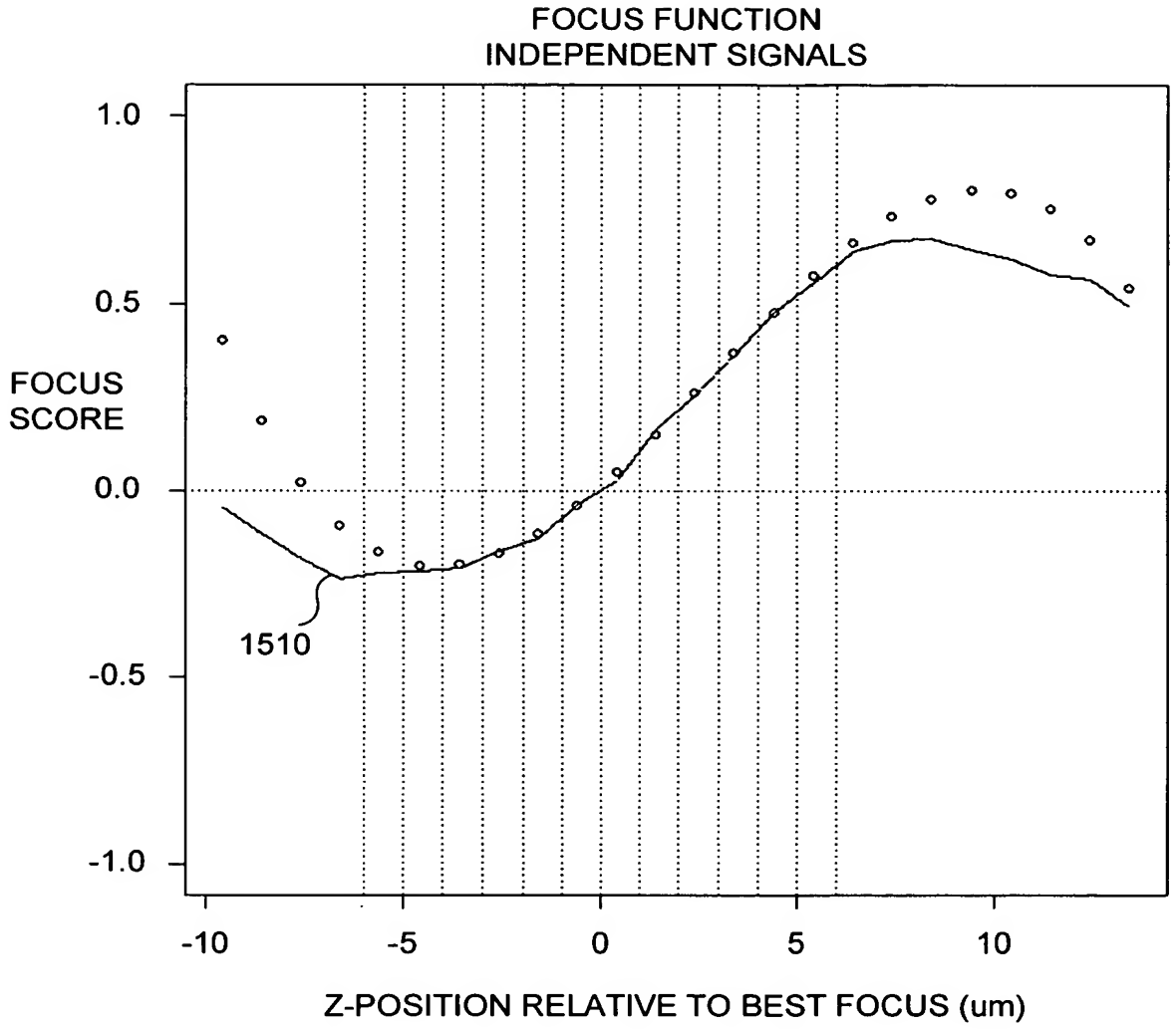

FOCUS FUNCTION
INDEPENDENT SIGNALS
1.0
0.5
0.0
-0.5
-1.0
FOCUS
SCORE
1510
-10
-5
0
5
10
Z-POSITION RELATIVE TO BEST FOCUS (um)

FIG. 15A

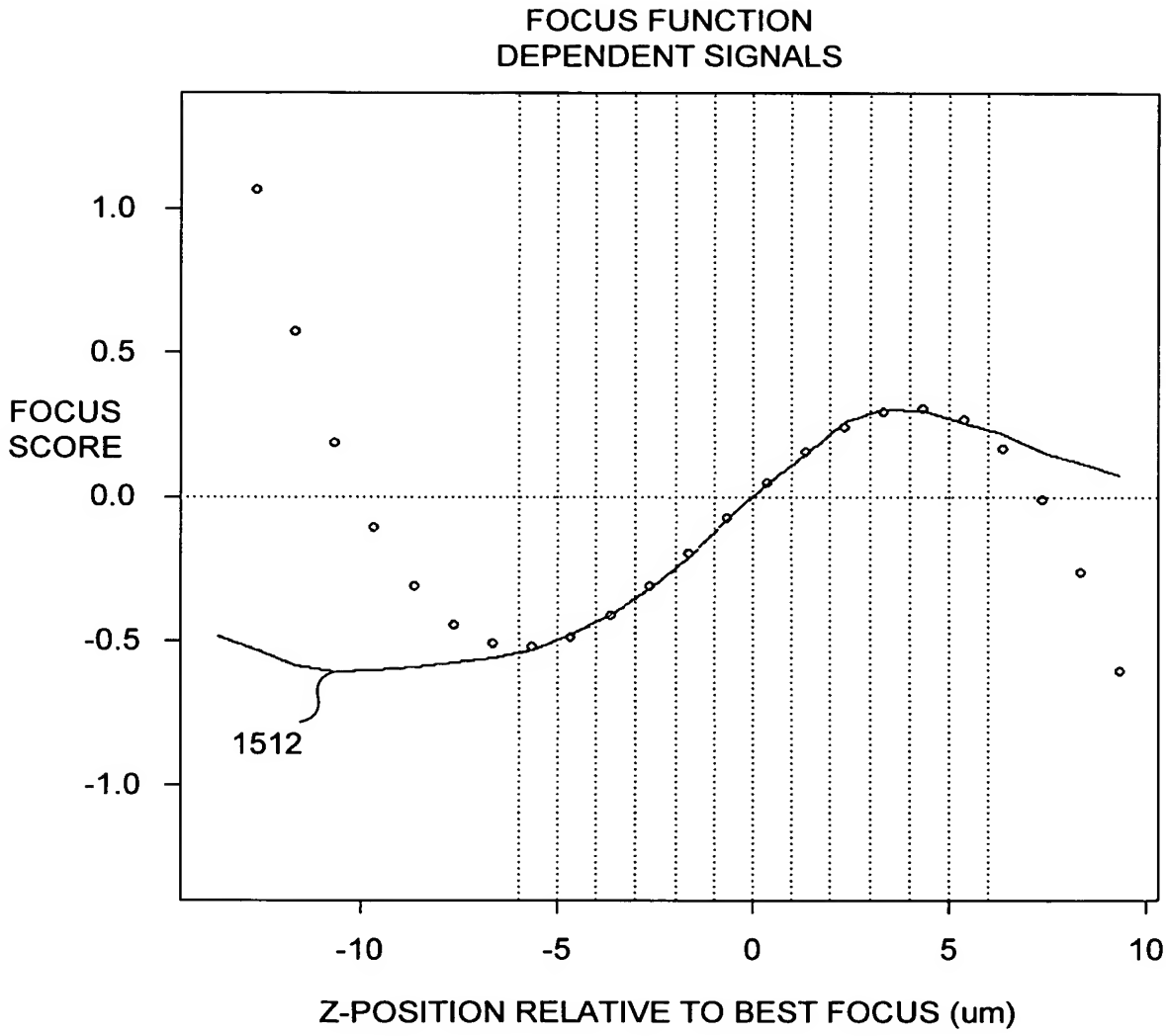

FOCUS FUNCTION
DEPENDENT SIGNALS
1.0
0.5
FOCUS
SCORE
0.0
-0.5
-1.0
1512
-10
-5
0
5
10
Z-POSITION RELATIVE TO BEST FOCUS (um)

FIG. 15B

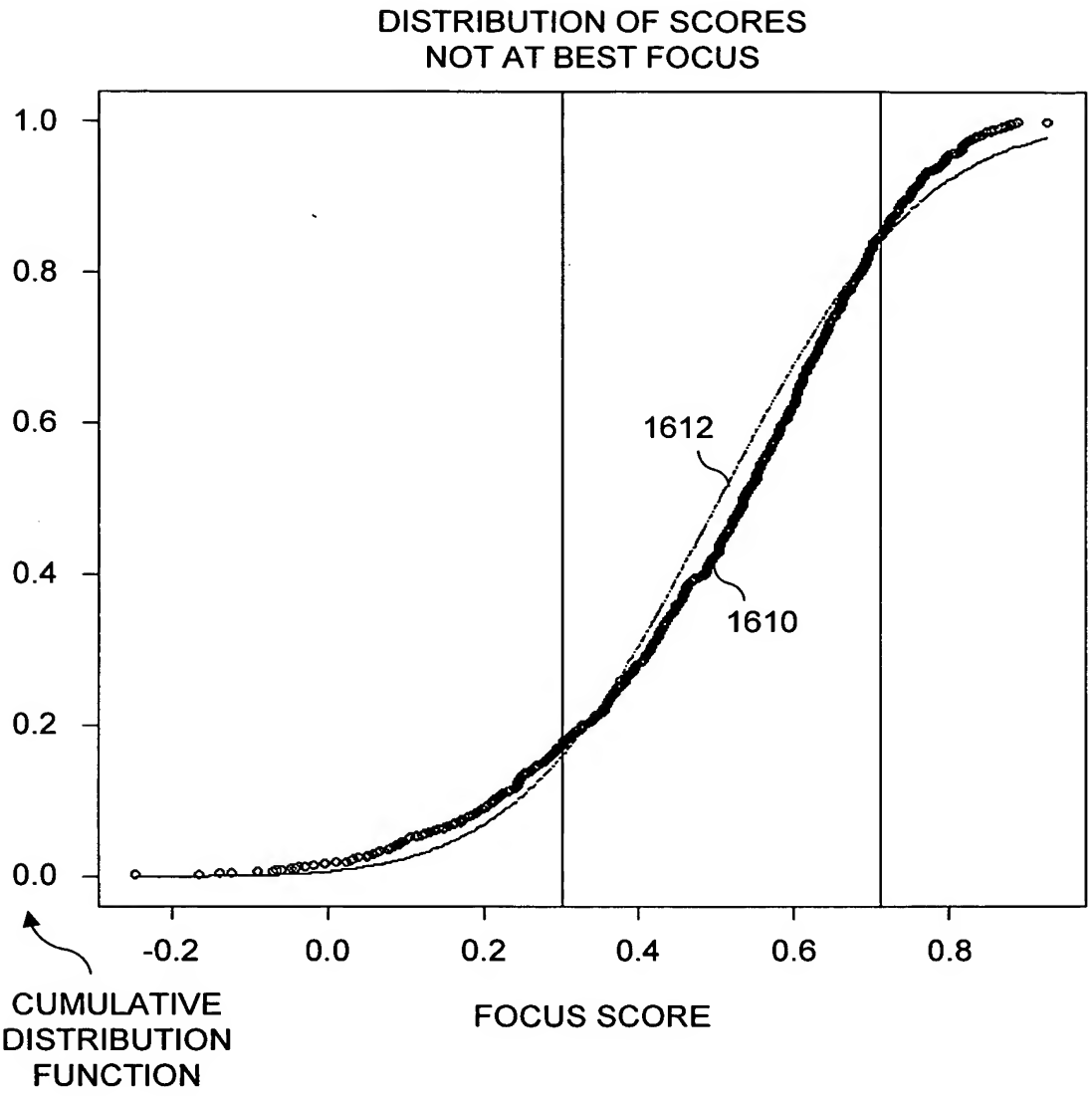

DISTRIBUTION OF SCORES
NOT AT BEST FOCUS
1.0
0.8
0.6
0.4
0.2
0.0
1612
1610
-0.2
0.0
0.2
0.4
0.6
0.8
CUMULATIVE
DISTRIBUTION
FUNCTION
FOCUS SCORE

FIG. 16A

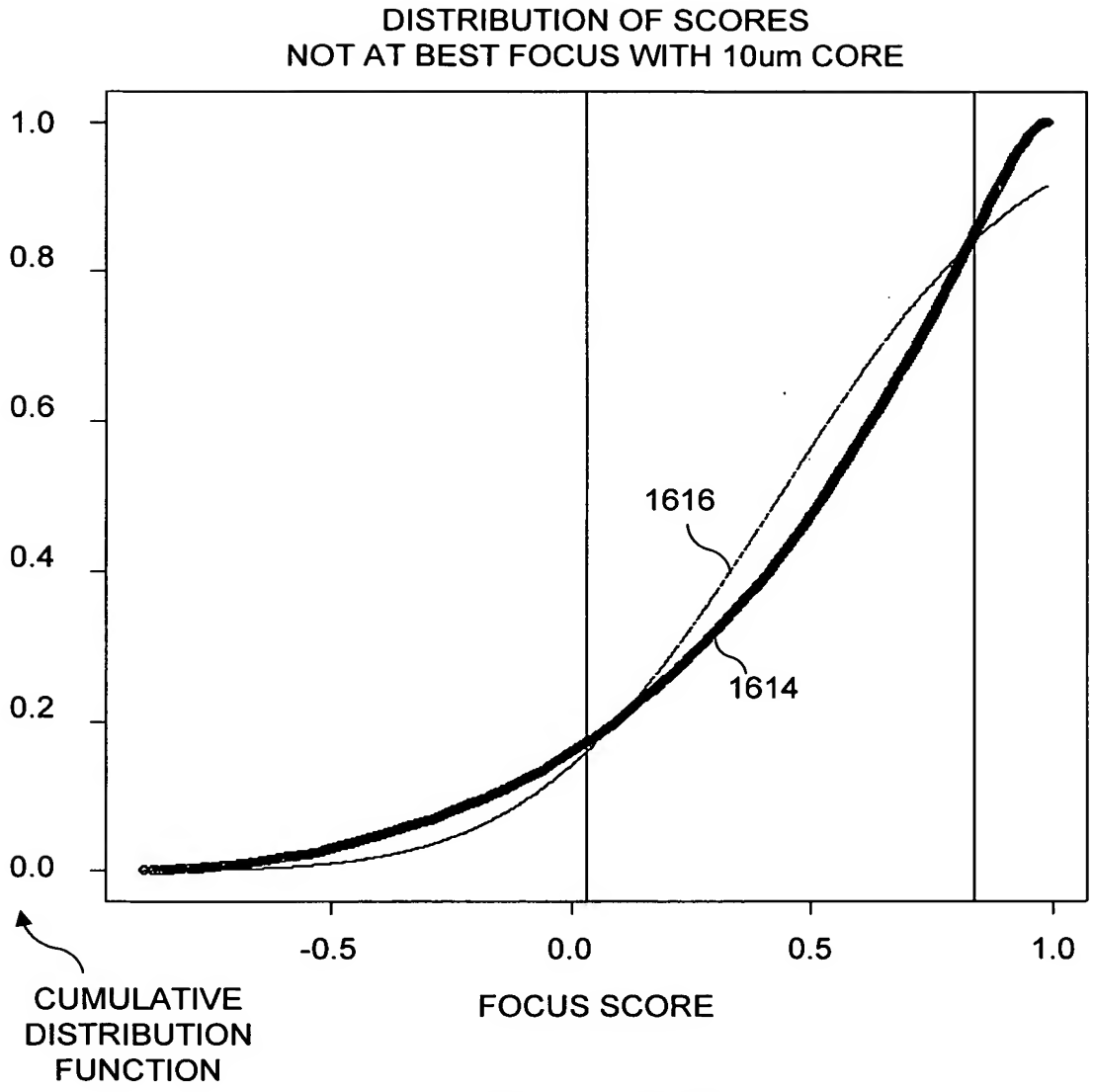

DISTRIBUTION OF SCORES
NOT AT BEST FOCUS WITH 10um CORE
1.0
0.8
0.6
0.4
0.2
0.0
1616
1614
-0.5
0.0
0.5
1.0
CUMULATIVE
DISTRIBUTION
FUNCTION
FOCUS SCORE

FIG. 16B

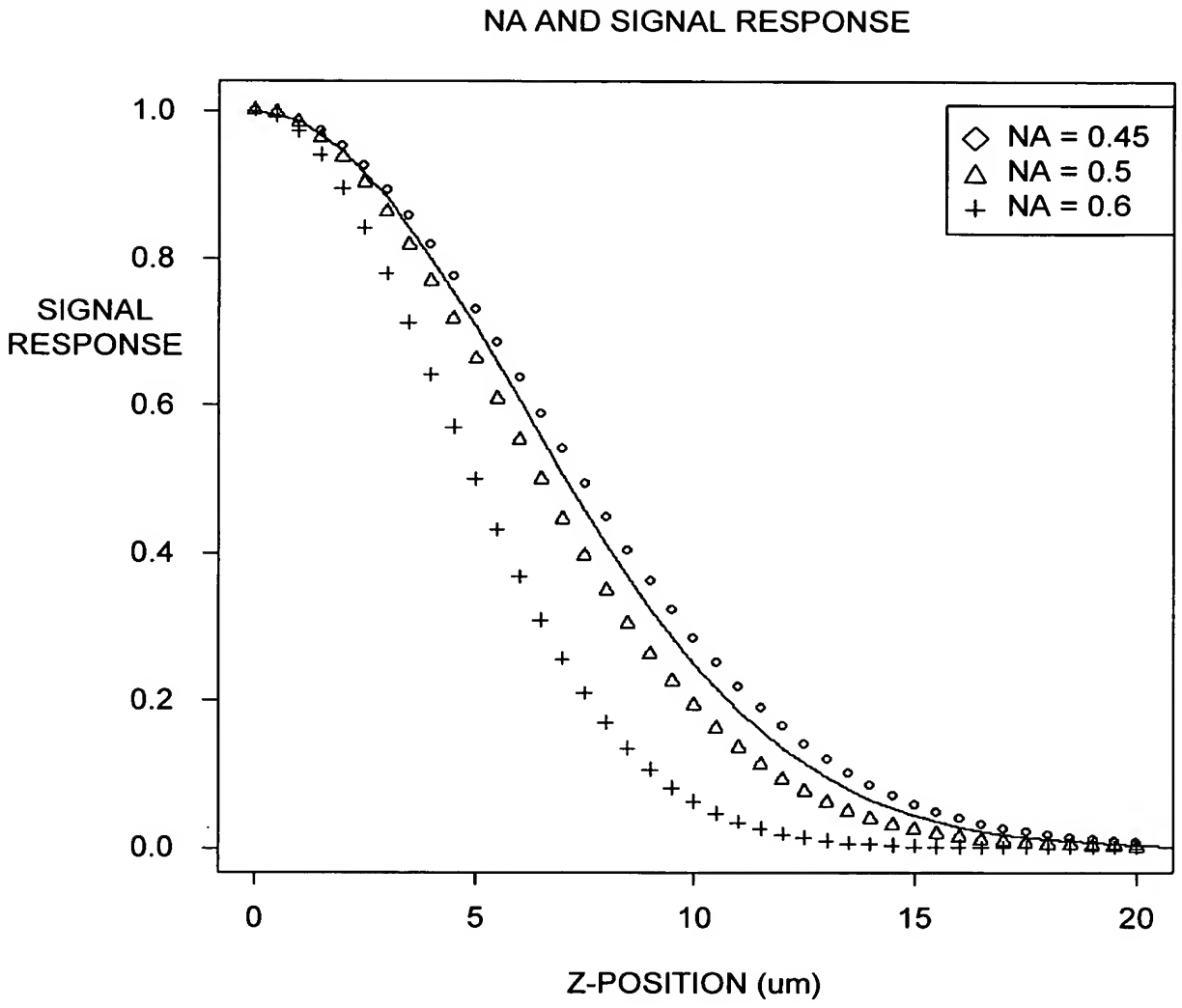

NA AND SIGNAL RESPONSE
SIGNAL RESPONSE
1.0
0.8
0.6
0.4
0.2
0.0
0
5
10
15
20
Z-POSITION (um)
NA = 0.45
NA = 0.5
NA = 0.6

FIG. 17

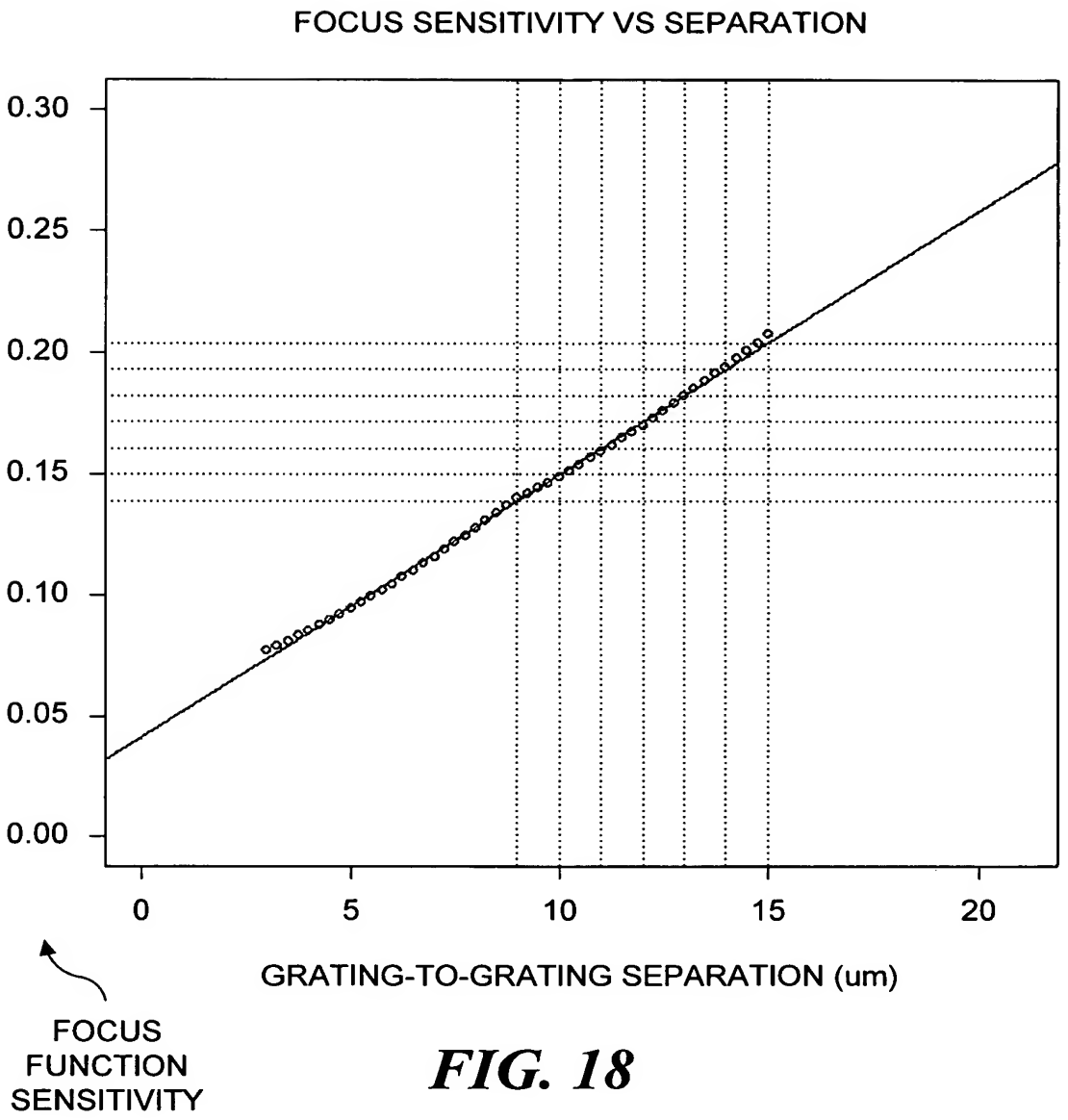

FOCUS SENSITIVITY VS SEPARATION
0.30
0.25
0.20
0.15
0.10
0.05
0.00
0
5
10
15
20
GRATING-TO-GRATING SEPARATION (um)
FOCUS
FUNCTION
SENSITIVITY

FIG. 18

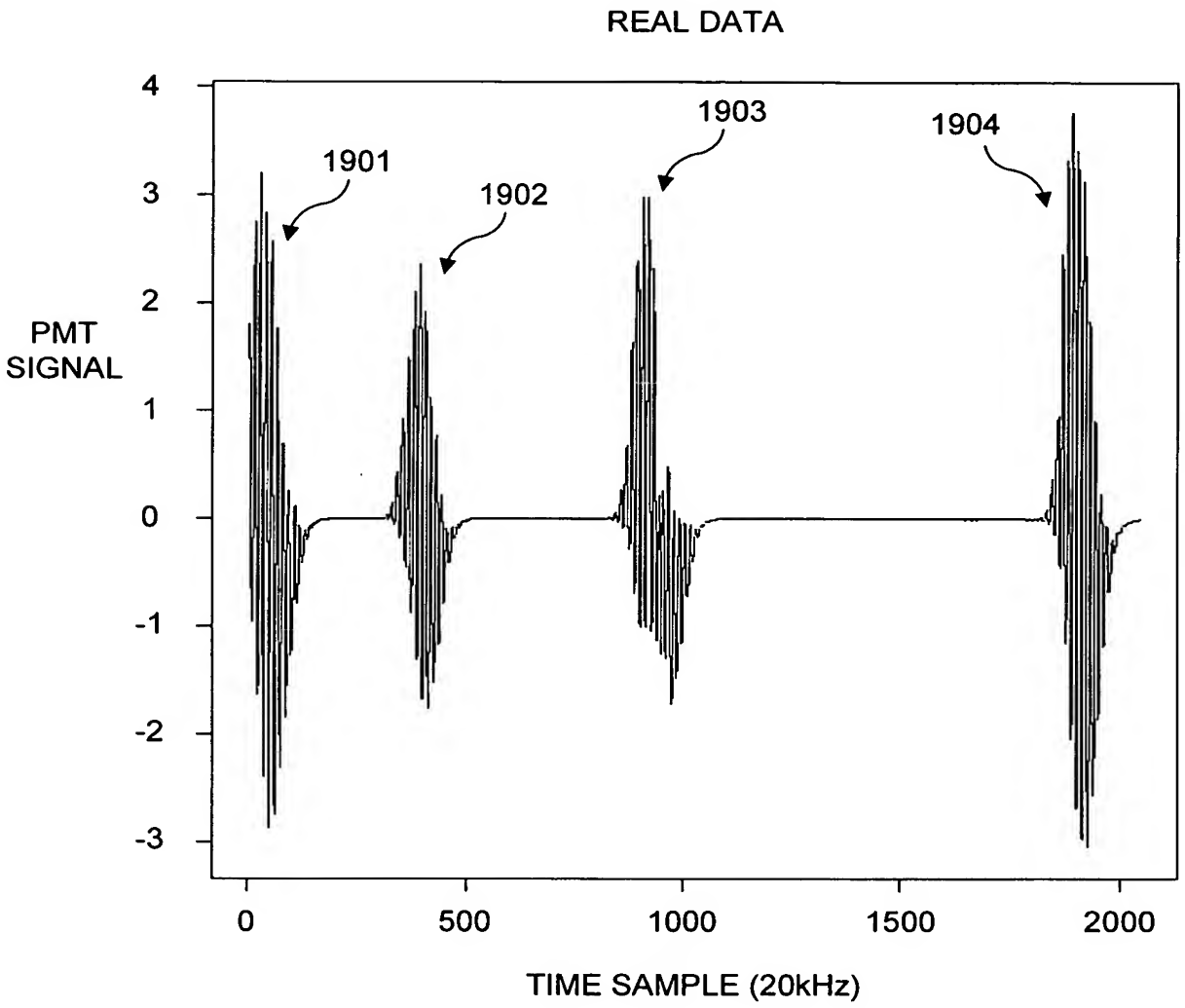

REAL DATA
PMT SIGNAL
4
3
2
1
0
-1
-2
-3
1901
1902
1903
1904
0
500
1000
1500
2000
TIME SAMPLE (20kHz)

FIG. 19

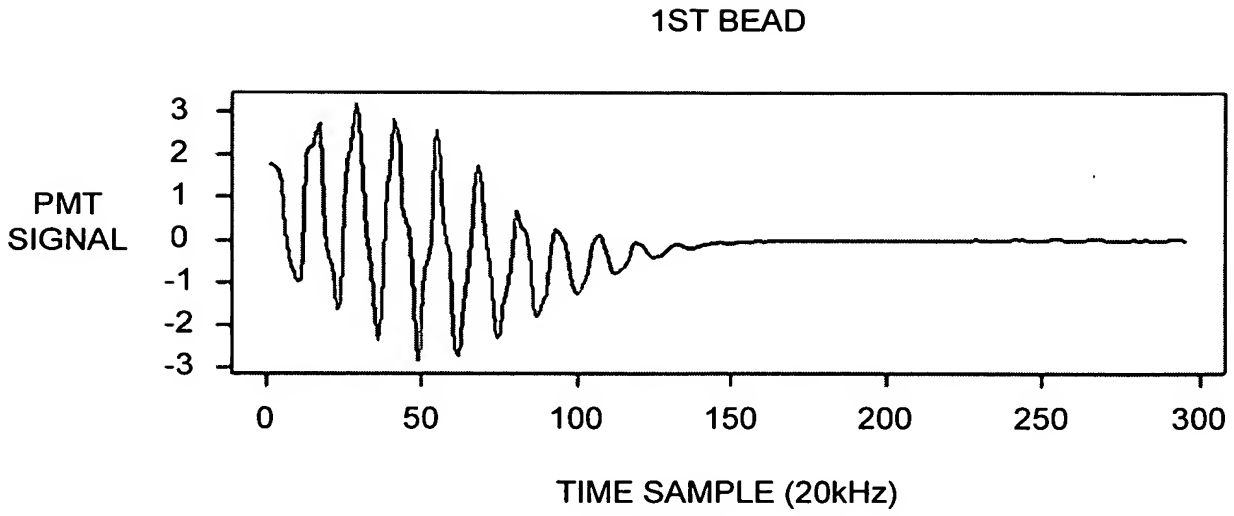


FIG. 20A

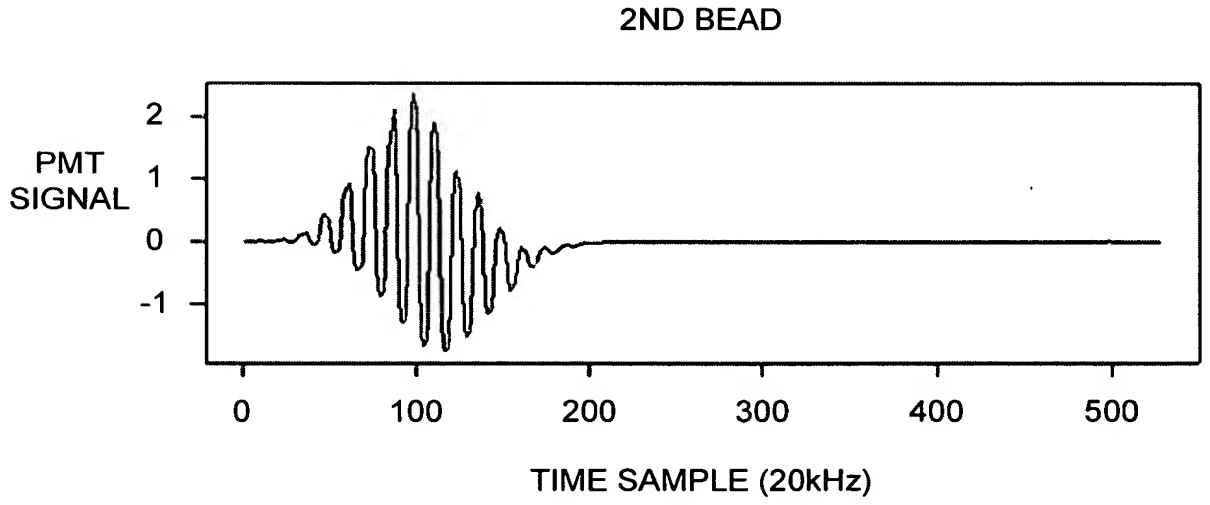


FIG. 20B

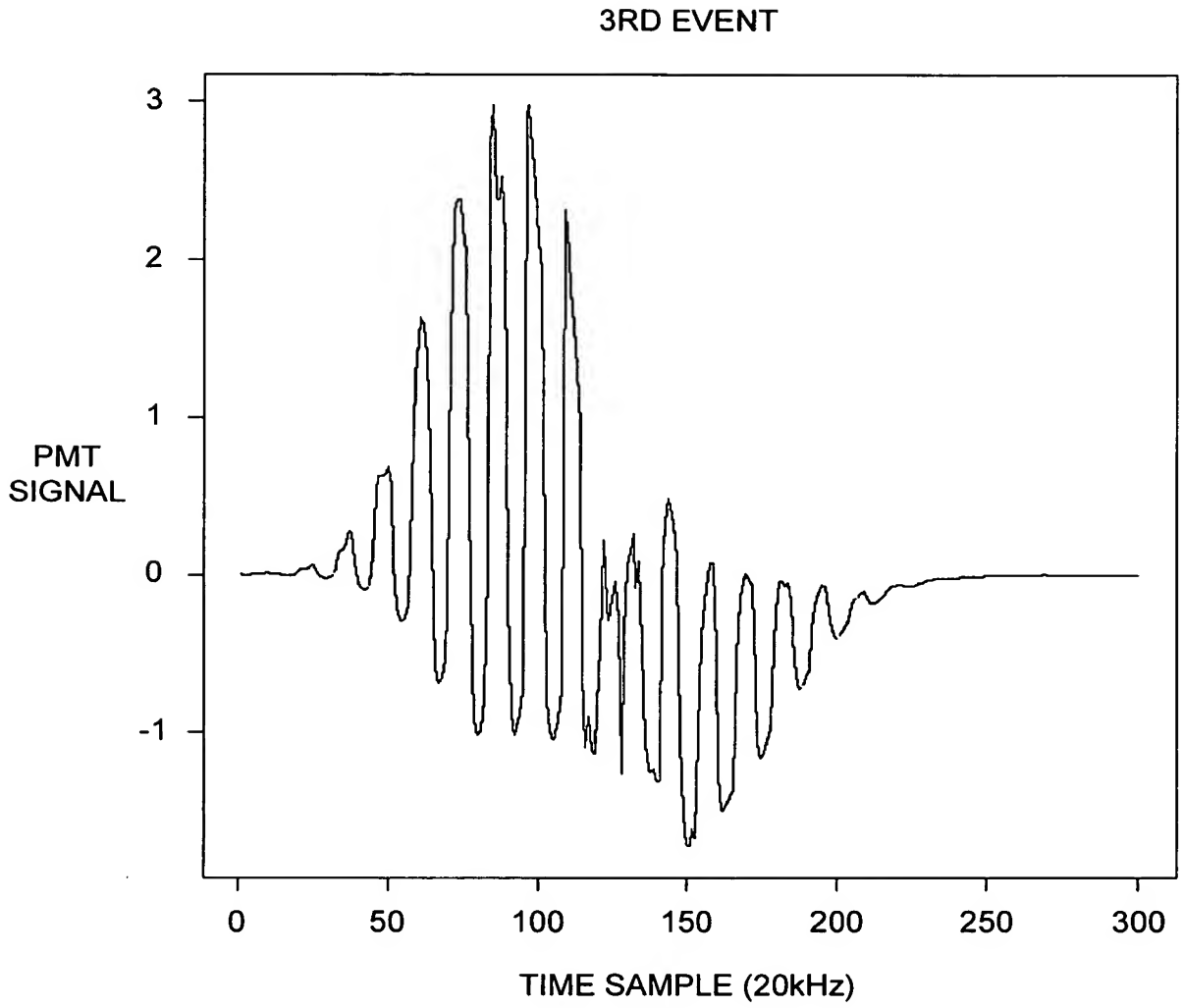

3RD EVENT
PMT SIGNAL
3
2
1
0
-1
0
50
100
150
200
250
300
TIME SAMPLE (20kHz)

FIG. 20C

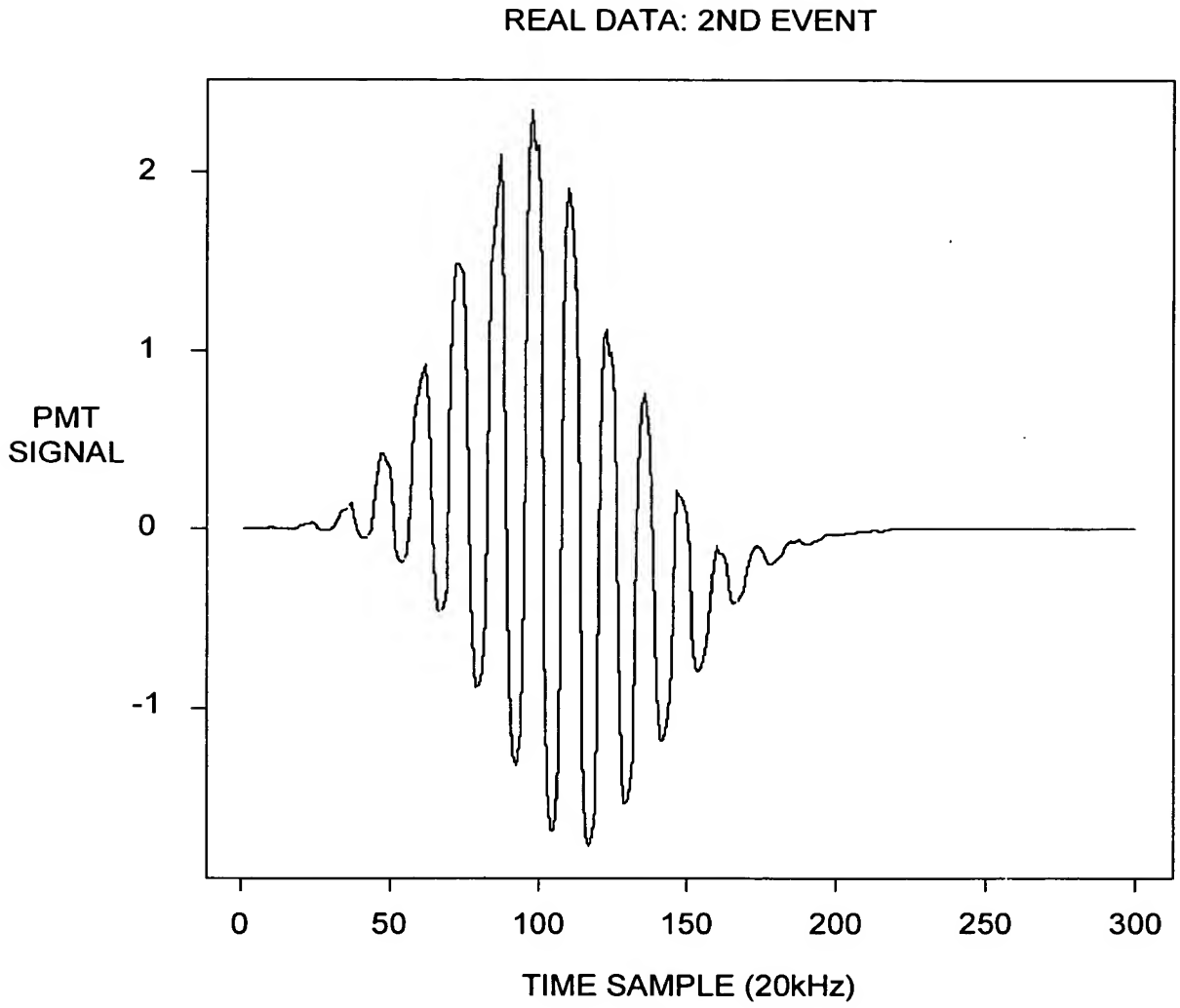

REAL DATA: 2ND EVENT
PMT SIGNAL
2
1
0
-1
0
50
100
150
200
250
300
TIME SAMPLE (20kHz)

FIG. 21A

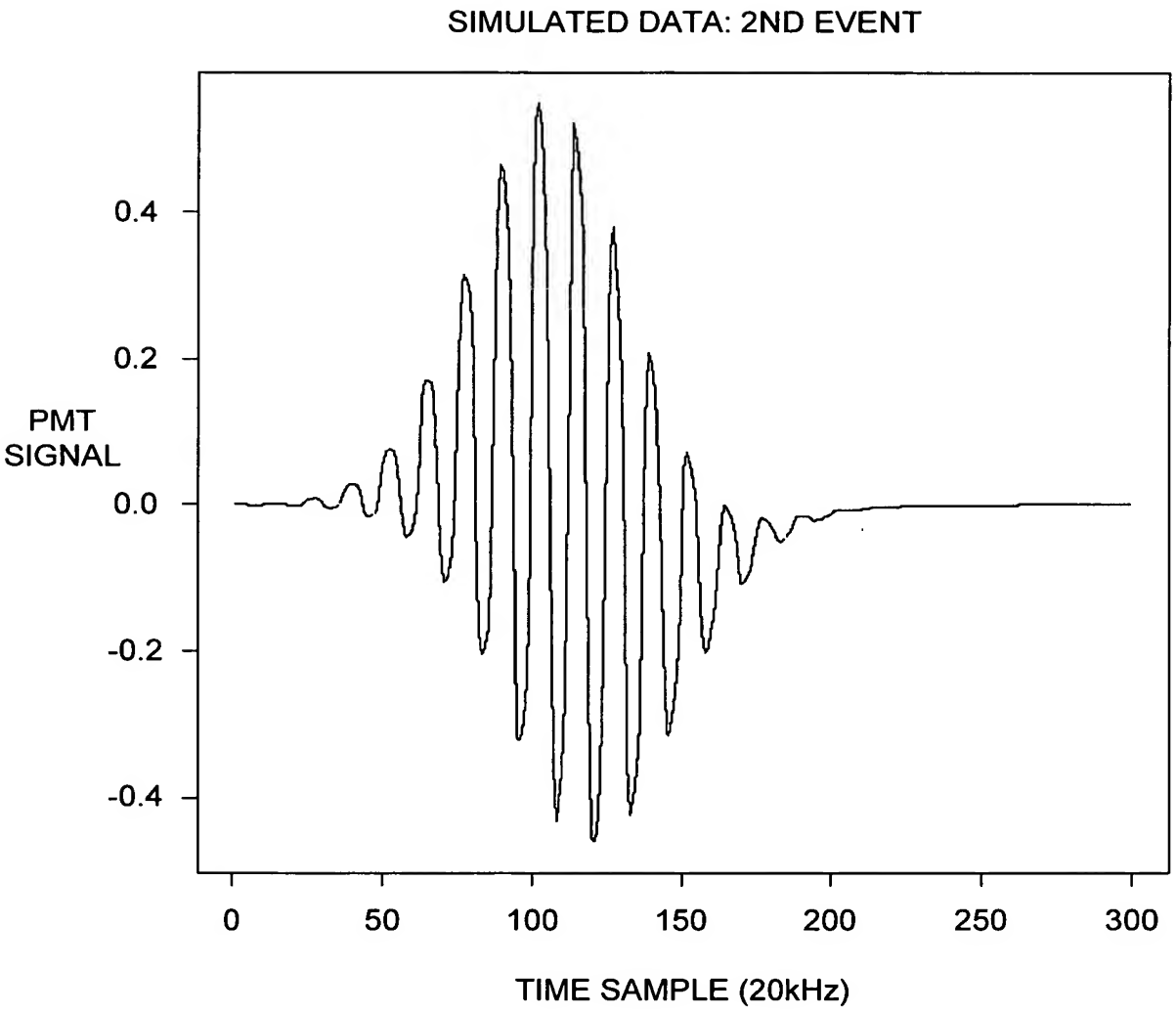

SIMULATED DATA: 2ND EVENT
PMT SIGNAL
0.4
0.2
0.0
-0.2
-0.4
0
50
100
150
200
250
300
TIME SAMPLE (20kHz)

FIG. 21B

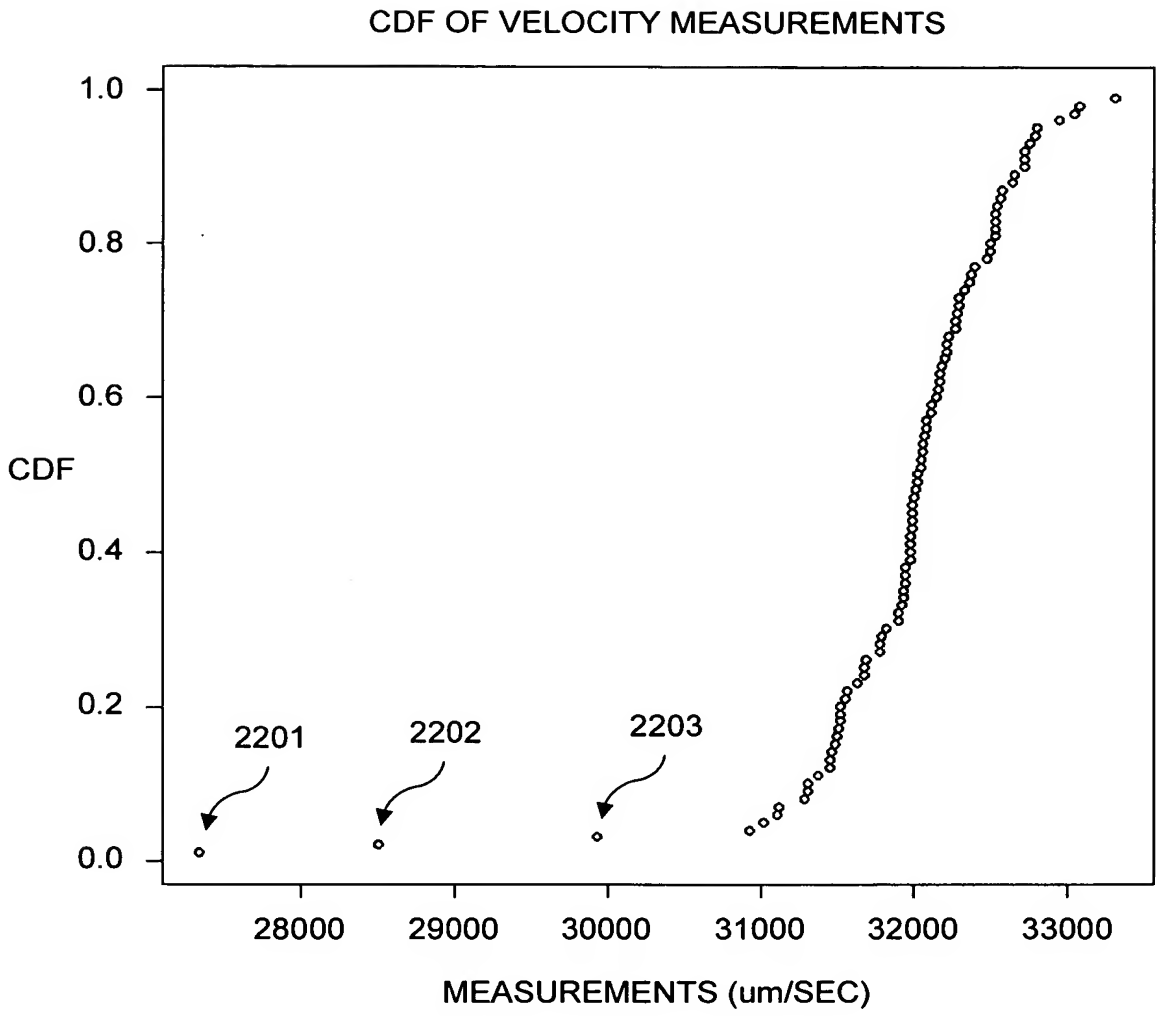

CDF OF VELOCITY MEASUREMENTS
1.0
0.8
0.6
CDF
0.4
0.2
0.0
2201
2202
2203
28000
29000
30000
31000
32000
33000
MEASUREMENTS (um/SEC)

FIG. 22

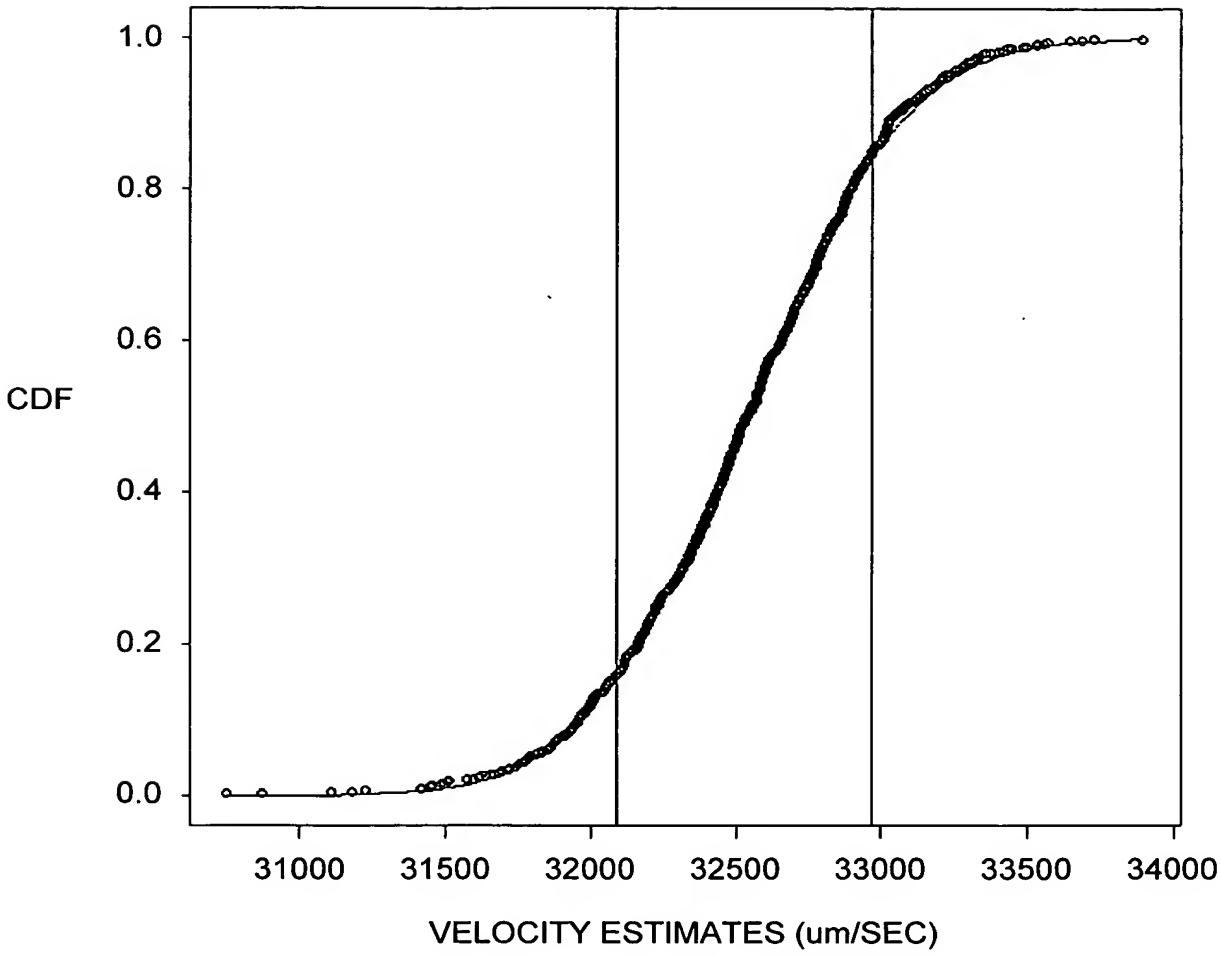

1.0
0.8
0.6
0.4
0.2
0.0
CDF
31000
31500
32000
32500
33000
33500
34000
VELOCITY ESTIMATES (um/SEC)

FIG. 23A

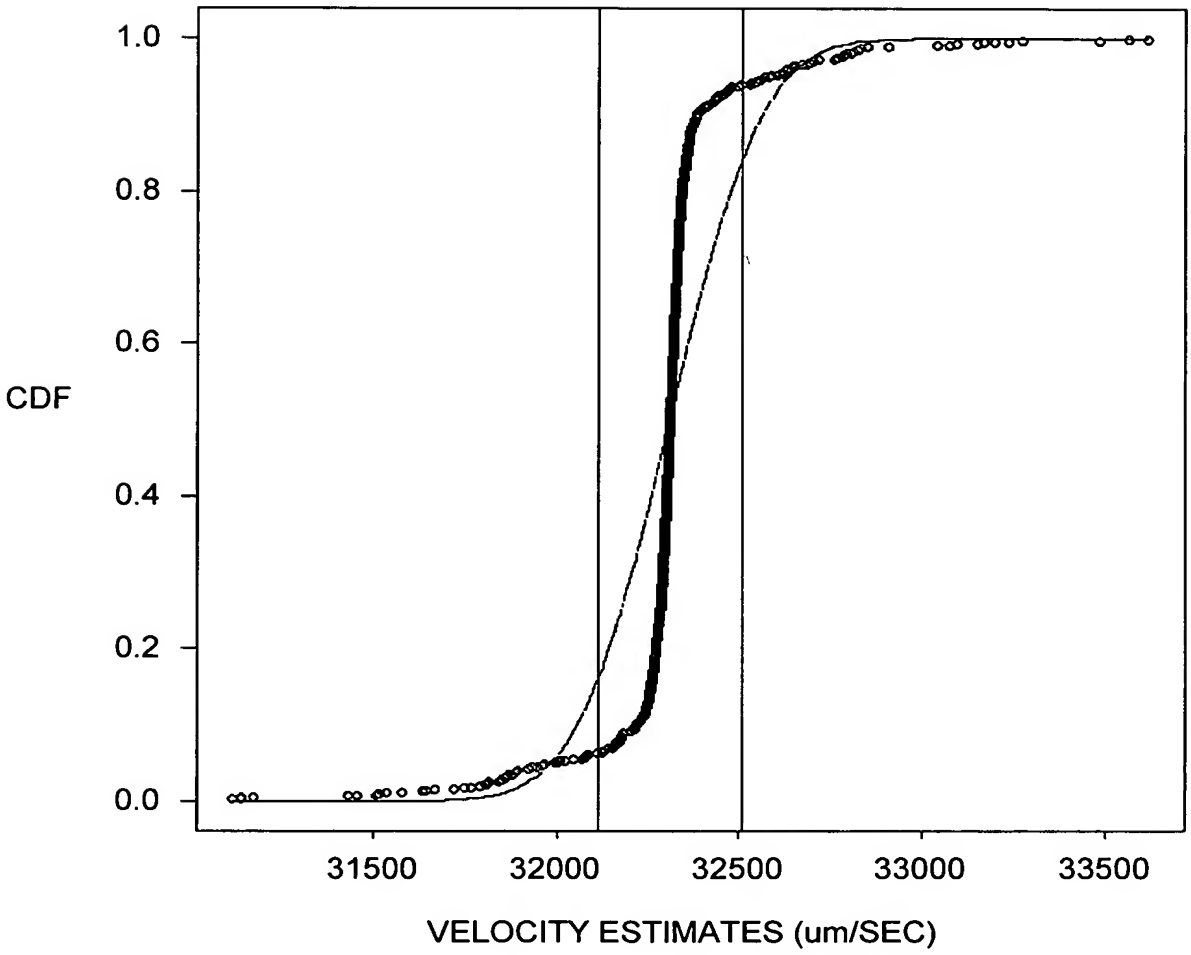

1.0
0.8
0.6
0.4
0.2
0.0
CDF
31500
32000
32500
33000
33500
VELOCITY ESTIMATES (um/SEC)

FIG. 23B

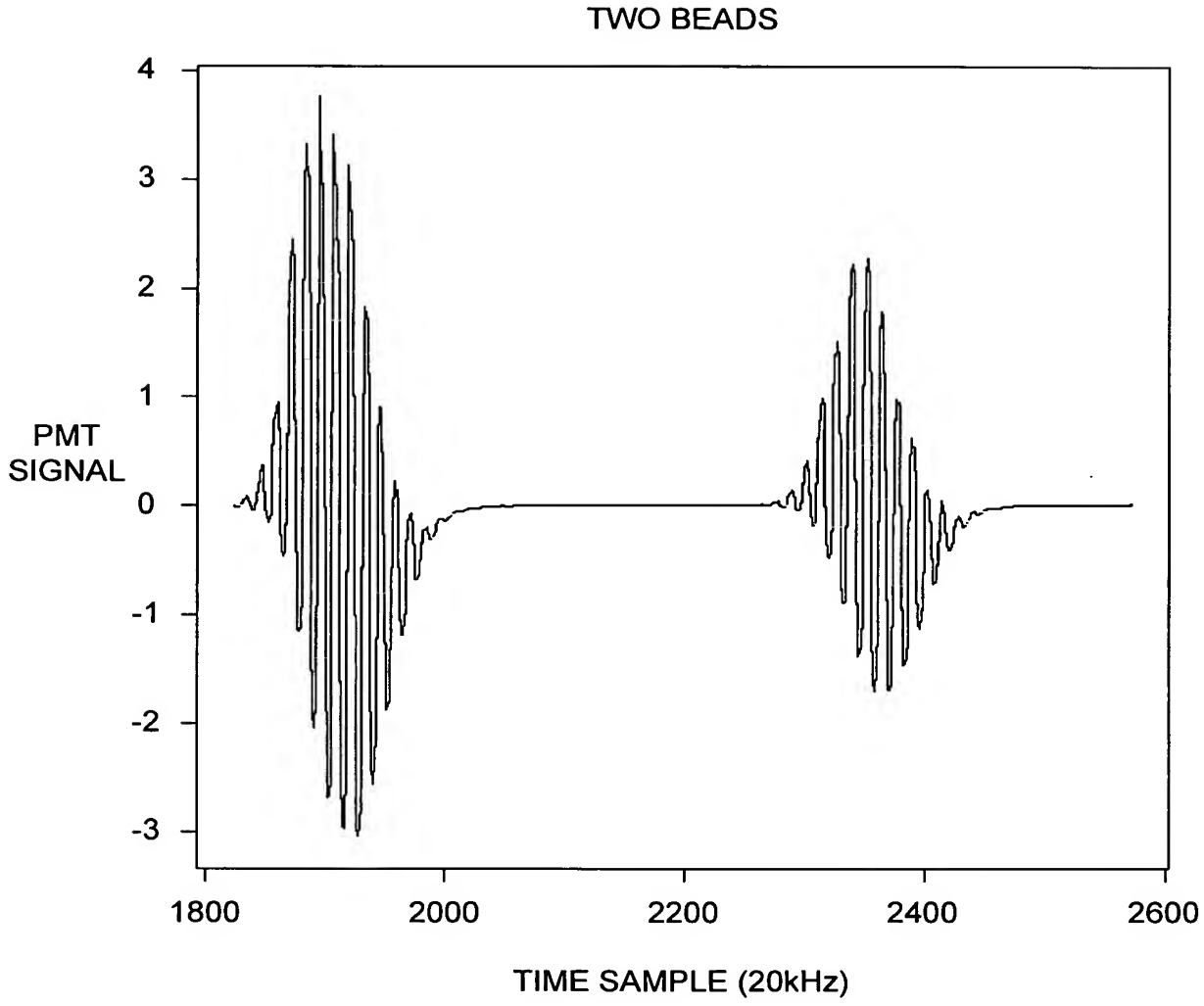

TWO BEADS
PMT SIGNAL
4
3
2
1
0
-1
-2
-3
1800
2000
2200
2400
2600
TIME SAMPLE (20kHz)

FIG. 24

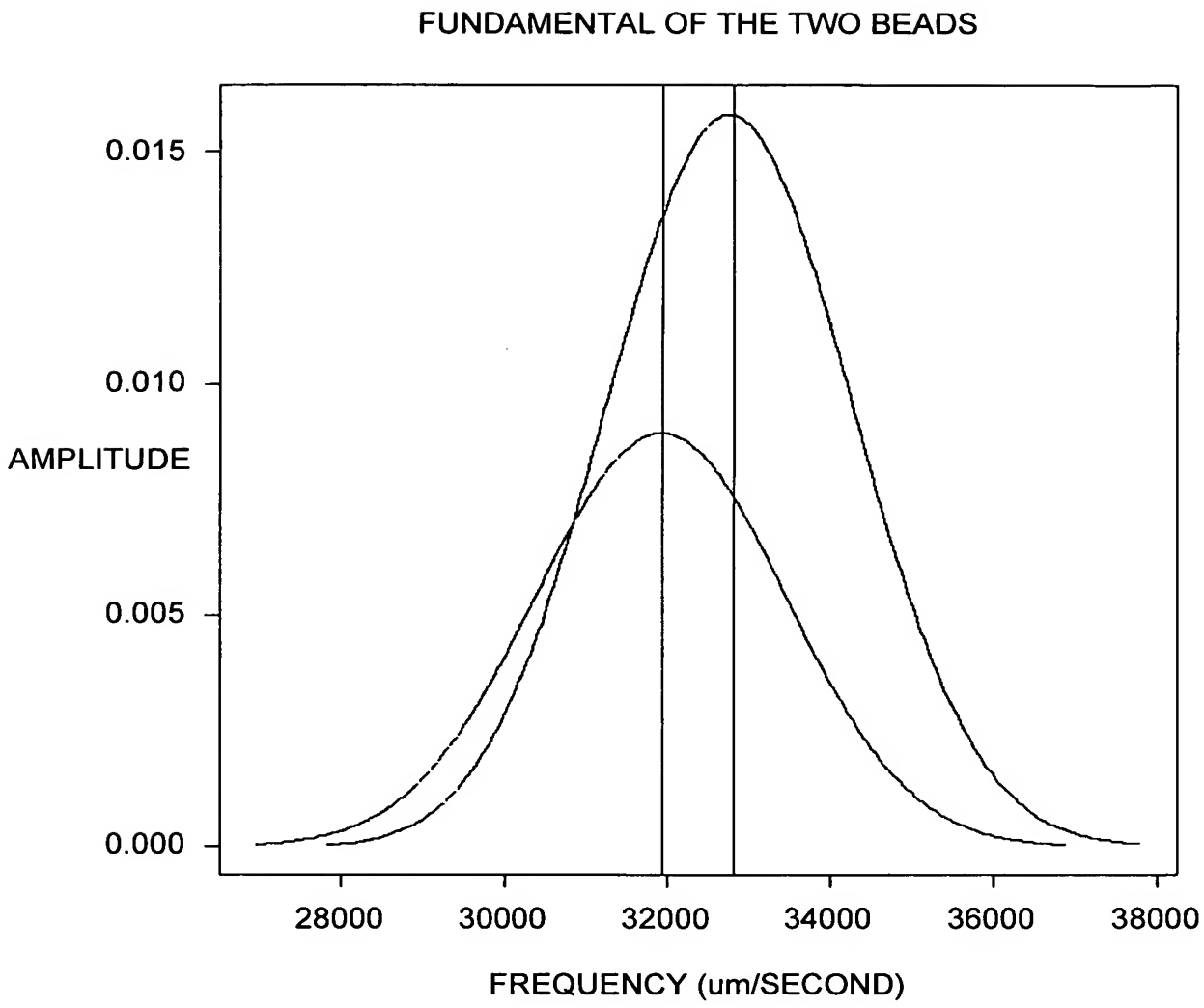

FUNDAMENTAL OF THE TWO BEADS
0.015
0.010
AMPLITUDE
0.005
0.000
28000
30000
32000
34000
36000
38000
FREQUENCY (um/SECOND)

FIG. 25

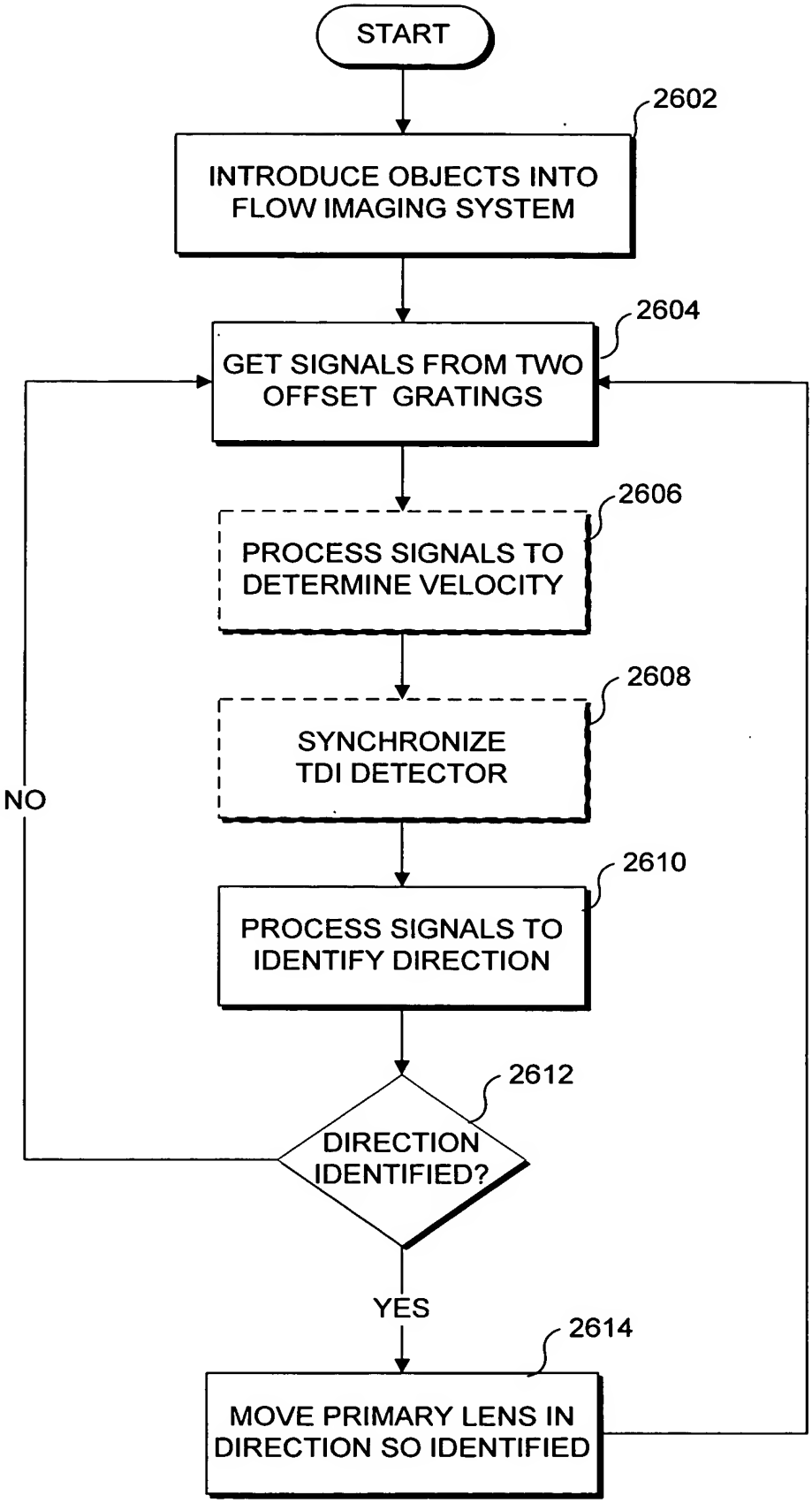

START
2602
INTRODUCE OBJECTS INTO FLOW IMAGING SYSTEM
2604
GET SIGNALS FROM TWO OFFSET GRATINGS
2606
PROCESS SIGNALS TO DETERMINE VELOCITY
2608
SYNCHRONIZE TDI DETECTOR
2610
PROCESS SIGNALS TO IDENTIFY DIRECTION
2612
DIRECTION IDENTIFIED?
NO
YES
2614
MOVE PRIMARY LENS IN DIRECTION SO IDENTIFIED

FIG. 26